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QUARRY RESIDUALS SAMPLING PLAN

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JANUARY 1994 **REV. 1**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

DOE/OR/21548-382

Weldon Spring Site Remedial Action Project

Quarry Residuals Sampling Plan

Revision 1

January 1994

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for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

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MK-FERGUSON A MORRISON KNUDSEN COMPANY Weldon Spring Site Remedial Action Project Contract No. DE-AC05-86OR21548	 Rev. No. 1
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APPROVALS

Originator	1-18-94 Date
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1 INTRODUCTION

The U.S. Department of Energy (DOE) is responsible for cleanup activities at the Weldon Spring site under its Environmental Restoration and Waste Management Program. The major goals of this program are to eliminate the potential hazards to human health and the environment that are associated with contamination and, to the extent possible, to make surplus real property available for other uses.

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), requires that a Remedial Investigation/Feasibility Study (RI/FS) be performed to support the decision-making process for evaluating remedial action alternatives. Remedial actions at the Weldon Spring site have been divided into separate operable units (SOUs) to facilitate decision-making. Currently, four SOUs have been identified: (1) quarry bulk wastes, (2) the chemical plant site, (3) chemical plant groundwater, and (4) the quarry residuals area. (The quarry residuals area comprises the quarry proper and surrounding vicinity properties, including groundwater.)

To accomplish these goals, the DOE intends to conduct a comprehensive review and analysis of physical, contaminant, ecological, and other factors leading to the potential remediation of the quarry residuals area. These efforts will result in an RI report summarizing the nature, extent, and magnitude of contamination as well as the physical properties and characteristics of the area. The fate and transport of contamination must also be evaluated. The FS and the baseline assessment (BA) use data summarized in the RI to identify and evaluate alternatives for risk reduction. The regulatory requirements are detailed in the *Work Plan for the Remedial Investigation/Feasibility Study-Environmental Assessment for the Quarry Residuals Operable Unit at the Weldon Spring Site* (Work Plan) (ANL 1993).

The Work Plan summarizes the information necessary to fulfill these requirements for the Quarry Residuals Operable Unit (QROU). The *Quarry Residuals Sampling Plan* discusses data requirements and details the investigations necessary to meet them. Data collected during implementation of this sampling plan will be summarized in interpretive reports that support the RI.

Section 2 of this sampling plan provides background information which describes the area of investigation, site history, contaminant sources, and previous investigations. Section 3 gives the physical description of the geology, hydrogeology, and ecology of the site. Section 4 summarizes the active environmental investigations, Section 5 identifies data requirements, and Section 6 gives the data quality objectives (DQOs). Sections 7, 8, and 9, respectively, detail the hydrogeologic, contaminant, and ecological investigations to be performed. Section 10 presents quality control measures that will be implemented during investigations. Section 11 defines data interpretation and reporting requirements; Section 12 specifies the Health and Safety Program.

1.1 Purpose

This document provides a site-specific sampling plan that includes rationale, procedures, locations, and other details involved with the hydrogeologic, ecologic, and contaminant characterization of the quarry residuals for remedial investigation. The objectives of the sampling plan are to determine the radiological and chemical characterization of the air, soil, sediment, surface water, and groundwater near the quarry; to characterize physical processes governing mobility and migration of contaminants; and to provide information for characterization of the ecology of the operable unit.

1.2 Scope

Characterization efforts for the QROU will be performed in three phases. Phase I comprises those activities performed and/or initiated before the bulk wastes are removed from the quarry. Phase II comprises the sampling that will be performed after the bulk waste is removed. Phase III will fill in any remaining data gaps.

This sampling plan provides documentation for the implementation of the field work in Phase I necessary to provide a characterization of the area outside the quarry proper. The quarry residuals study area includes, but is not limited to, the area shown in Figure 2-2. The media to be evaluated for contamination are air, soil, sediment, surface water, and groundwater. Ecological characterization activities will include vegetation surveys, herpetofauna surveys, listed-species surveys, wetland determinations, and tissue analyses of species known to occur at the quarry area that may be consumed by humans or threatened or endangered species, and will allow a preliminary determination of ecological risk. Physical characterization will include installation of wells, sample collection and analysis, aquifer testing, and hydrological surveys.

The Contaminant Sampling Program (Section 8 of this plan) has been divided into two subphases, IA and IB, for surface water, sediment, and soil characterization. Groundwater characterization need not be divided into subphases since it is essentially one continual effort. Groundwater data will be available for Phase IA reporting. No air monitoring other than that specified in the Environmental Monitoring Program (DOE 5400.1) will be performed (see Section 8.5).

The data collected from this and previous investigations will be used to evaluate past and present conditions and to predict future impacts. Additional characterization (Phase II and Phase III) will be performed following completion of quarry bulk waste removal. Additional sampling plans will be developed to describe these efforts once they can be adequately scoped. Any radiological or chemical data not collected during this investigation, but that is later determined necessary, will be obtained during subsequent efforts.

1.3 Flood Effects

Anomalously high rainfall in 1993 resulted in record flooding of the Missouri River during the spring, summer, and fall. These conditions resulted in floodwaters of the Missouri River repeatedly overtopping levees protecting portions of the quarry residuals study area. While river stage has fluctuated in response to heavy rainfall, the system of levees along the river south of the quarry, which normally serve to protect the St. Charles County well field and Missouri Department of Conservation (MDOC) property from high water, have functioned to contain floodwaters. Breaching and patching of the east levee was conducted in August to promote drainage. However, invasion of the study area by floodwaters after breaching and patching has resulted in recontainment of floodwaters. Potential additional actions by St. Charles County, the MDOC, or the DOE to manage contained floodwater have not been determined as of November 1, 1993.

1.3.1 Schedule Impacts

The influence of flooding on the study area is difficult to determine at this time. Impacts from a planning perspective can be assessed from a limited standpoint relative to the amount of precipitation the Missouri River basin receives during late 1993 and early 1994. Assuming normal winter and spring conditions, it may be reasonable to initiate sampling and other field activities planned for flooded areas of the study area in mid 1994. Excessive precipitation during late 1993 and early 1994 could result in an extended period of flood behavior for the Missouri River basin and additional delays regarding residuals contaminant characterization efforts in the flood plain portion of the study area.

1.3.2 Routine Monitoring Impacts

Routine site environmental monitoring in the study area has been interrupted due to flooding. Since July 15, 1993, a total of 26 monitoring wells and eight St. Charles County production wells have been flooded and inaccessible at some time during this period. Most of these wells are located south of the Femme Osage Slough and provide critical information for well field contingency planning. It is not known when the floodwaters will recede sufficiently to allow sampling of the affected wells to resume. Sampling of county production wells, as well as treated and untreated water, has continued at an increased frequency as part of a modified monitoring strategy for this area. Monitoring results for this period have been generally consistent with historical data.

In September, a brief regression of floodwater allowed sampling of five monitoring wells (MW-1017 through MW-1023) located south of the Femme Osage Slough. Samples from these wells were analyzed for uranium using the site kinetic phosporscent analyzer (KPA). These results, while they are considered to be semi-quantitative, indicate conditions which are consistant with historical data for these locations.

1.3.3 Potential Impacts

Visual observations of portions of the study area over the past months suggest that silty sediments and miscellaneous debris have been deposited in the study area by floodwaters. It is possible that contaminants from upstream sources have been deposited in the study area by floodwaters. Additionally, some areas may have been subjected to erosion during flooding, resulting in redistribution of contaminants.

1.3.4 System Recovery

When conditions permit, the Project Management Contractor (PMC) will assess affected monitoring wells. It is estimated that sediment may have entered some wells through vent holes and these wells will require redevelopment to obtain representative samples. Additionally, at least two rounds of routine data should be examined to assess the appropriateness of initiating more comprehensive analyses as part of the residuals characterization program.

2 BACKGROUND

This section describes the quarry residuals study area, summarizes site history, discusses contaminant sources, and reviews pertinent investigations performed prior to the Quarry Residuals Remedial Investigation (QRRI).

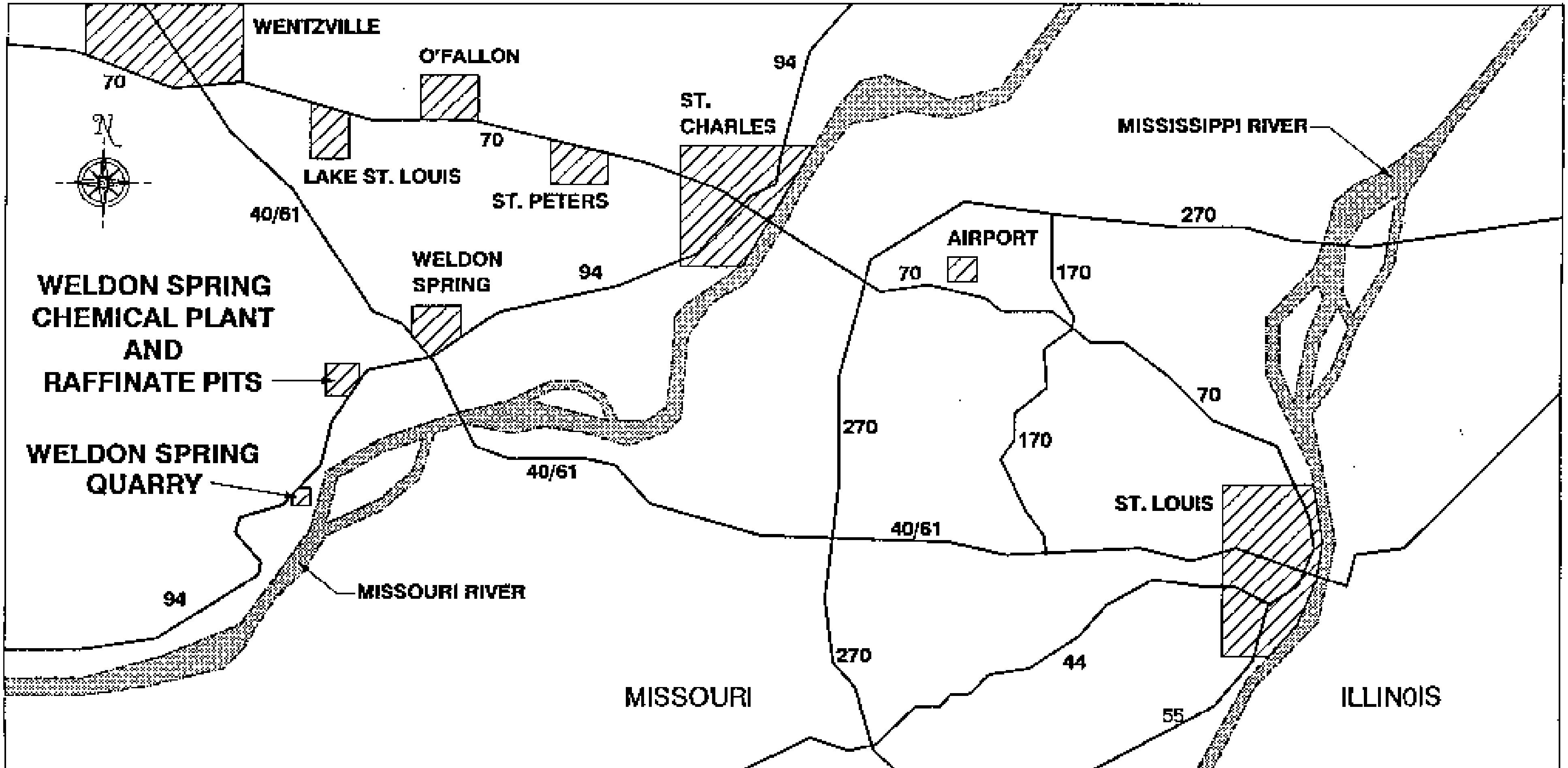
2.1 Site Location and Description

The Weldon Spring quarry is located between Defiance and Weldon Spring, Missouri, about 48 kilometers (30 mi) west of St. Louis (Figure 2-1). Additional definition of the quarry residuals study area is presented in Figure 2-2. The study area consists of the quarry basin and surrounding areas. The 3.9 ha (9-acre) quarry was excavated into the limestone, bluff-forming walls of the Missouri River floodplain. The relatively flat alluvial floodplain extends southward from the bluff to the Missouri River, with natural relief of less than 3 m (12 ft). The topography of the areas north of the quarry is rugged and characterized by valleys deeply incised into the predominantly carbonate upland bedrock. The total relief approaches 30 m (100 ft).

Surface water resources of the study area include the Femme Osage Slough, Femme Osage and Little Femme Osage Creeks, and the Missouri River (Figure 2-2). Water present in a small pond in the quarry is currently scheduled to be removed and treated; this action will be performed in support of quarry bulk waste removal and is described in further detail in the *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (MacDonell et al. 1989). Environmental monitoring has detected contamination in the quarry pond and the Femme Osage Slough surface water.

Groundwater at the study area occurs in alluvial sediments associated with the Missouri River and Femme Osage and Little Femme Osage Creeks, as well as in Paleozoic carbonate and sandstone bedrock units. Nine production wells completed in the alluvium south of the slough supply water to portions of St. Charles County to a maximum capacity of 90 million liters/day (mld) (24 MGD).

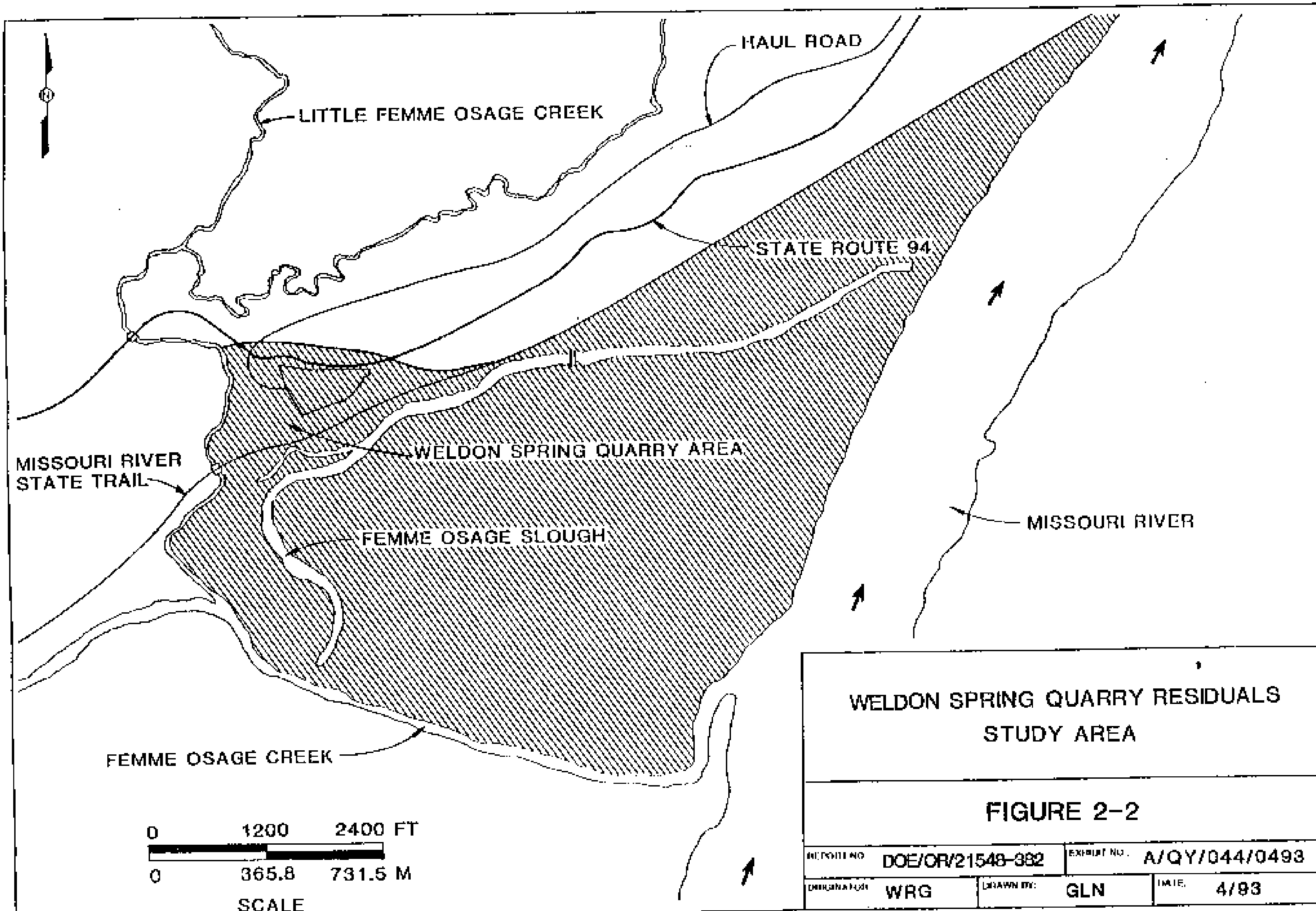
Other resources of the area include the diverse Weldon Spring Wildlife Area, a public-use area which surrounds the quarry and is part of the study area, and the Katy Trail.



LOCATION OF THE WELDON SPRING SITE

FIGURE 2-1

REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/VP/025/0393
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 11/02/93



WELDON SPRING QUARRY RESIDUALS
STUDY AREA

FIGURE 2-2

REPORT NO.	DOE/OR/21548-382	EXHIBIT NO.	A/QY/044/0493
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2.2 Site History

The relevant history of the study area began in 1941 with the excavation of limestone aggregate from the quarry to support Weldon Spring Ordnance Works (WSOW) construction. The quarry was then intermittently used by the U.S. Department of the Army (DA) and the U.S. Atomic Energy Commission (AEC) for waste disposal from 1942 to 1969. The lands surrounding the quarry were also used to support the operation of the WSOW, with the Missouri River alluvium supplying water used in the production of trinitrotoluene (TNT) and dinitrotoluene (DNT). These lands were then transferred to the University of Missouri, which operated an experimental farm from 1949 until 1978. Approximately 2880 ha (7200 acres) were then sold to the Missouri Department of Conservation (MDOC), and the Weldon Spring Wildlife Area was established.

The Weldon Spring Site Remedial Action Project (WSSRAP) was created in 1984 and a project office established in 1986. The environmental documentation process supporting the removal of quarry bulk wastes was completed on September 28, 1990, with the issuance of a Record of Decision (ROD). Additional historical information is presented in the Work Plan (ANL 1993).

2.3 Contaminant Sources

Wastes placed in the quarry by the DA and the AEC comprise the primary contaminant source for this investigation. These wastes consist of chemically and radioactively contaminated soil, sludge, and debris. Table 2-1 presents a summary of historical waste disposal activities. Additional information on the characteristics of the bulk wastes is available in the *Remedial Investigation for Quarry Bulk Wastes* (MKF and JEG 1989a).

The quarry is a closed basin, and precipitation falling in the quarry that is not lost to evaporation and transpiration percolates through the bulk wastes. As a result, contaminants have dissolved and migrated via groundwater to areas outside of the quarry perimeter. Environmental monitoring and other characterization efforts have detected the presence of chemical and radiological contaminants in soils, groundwater, surface water, and sediment. These areas may represent additional contaminant sources once the bulk wastes are removed.

TABLE 2-1 History of Disposal Activities at the Weldon Spring Quarry

TIME PERIOD	WASTE TYPE	ESTIMATED VOLUME*	
		m^3	yd^3
1942 - 1945	TNT and DNT waste.	- - -[a]	- - -[a]
1946	TNT and DNT waste.	[b]	[b]
1946 - 1957	TNT and DNT residues and contaminated rubble from cleanup of the ordnance works (in deepest part and in northeast corner of quarry).	- - -[a]	- - -[a]
1959	3.8% thorium residues (drummed; currently below water level).	150	200
1960 - 1963	Uranium- and radium-contaminated rubble from demolition of the St. Louis Destrehan Street feed plant (covering 0.4 ha [1 acre] to a 9-m [30-ft] depth in deepest part of quarry).	38,000	50,000
1963 - 1966	High-thorium-content waste (in northeast corner of quarry).[c]	760	1,000
1963 - 1966	Uranium and thorium residues from the chemical plant and off-site facilities; building rubble and process equipment (both drummed and uncontained).	- - -[a]	- - -[a]
1966	3.0% thorium residues (drummed, placed above water level in northeast corner of quarry); TNT residues from cleanup of the ordnance works (placed to cover the drums).	460	600
1968 - 1969	Uranium- and thorium-contaminated rubble and equipment from interiors of some chemical plant buildings (101, 103, and 105).	4,600	6,000

(a) Hyphens indicate that the waste volume estimate is not available.
(b) An estimated 90 tons of TNT/DNT waste was disposed of in 1946.
(c) This was a portion of the waste originally stored at the Army arsenal in Granite City, Illinois; most of this material was subsequently removed from the quarry for the purpose of recovering rare earth elements.

Source: MKF and JEG 1989a

2.4 Historical Investigations

The study area has been investigated by numerous entities since 1942. These investigations can be summarized into two categories: (1) regional investigations and (2) investigations specifically designed to evaluate the effects of waste disposal on the surrounding area. The investigations relevant to this sampling plan are summarized in Table 2-2 and are discussed in the following subsections.

2.4.1 Regional Investigations

USGS 1944: This investigation focused on the problems associated with ordnance works waste disposal in the area of the Weldon Spring Chemical Plant. Results relevant to the quarry residuals effort included a general description of the regional geology and the occurrence of groundwater and surface water on the entire ordnance works (Fishel and Williams 1944).

USGS 1951: The AEC authorized this investigation to evaluate the occurrence of groundwater in the Weldon Spring area in support of location selection and design of special structures contemplated by the AEC. This report summarized the geology, topography, and hydrology of the ordnance works (Roberts and Theis 1951).

USGS 1983-1986: Several studies were performed during this period, refining the understanding of the regional geologic and hydrogeologic setting. Geochemical and contaminant analyses were performed, primarily in support of investigations being performed at the Weldon Spring Chemical Plant/raffinate-pit area.

TABLE 2-2 Summary of Major Historical Investigations

DATE	LEAD AGENCY*	CONTRACTOR* (AUTHOR/REFERENCE)	MAIN ACTIVITY
1944	DA	USGS (Fishel and Williams)	Regional geology and hydrology.
1951	AEC	USGS (Robert & Theis)	Regional geology and hydrology.
1960 - 1961	AEC	USGS (Richardson)	Well monitoring and aquifer testing.
1976	AEC	NLO (Pennak)	Geology and hydrogeology.
1976 - 1977	AEC	NLO (Huey)	Well monitoring - groundwater quality.
1979 - 1984	DOE	LBL (BGA 1984)	Geologic characterization and aquifer testing.
1982 - 1986	DOE	BNI (BNI 1985)	Rejuvenating and installing monitoring wells; radiological survey.
1983 - 1986	DOE	USGS (Kleeschulte and Emmett)	Regional hydrogeology and summary of previous data.
1986	St. Charles County	Layne-Western	Aquifer testing.
1986	DOE	TMA/Eberline	Sediment and soil characterization.
1987 - 1991	DOE	PMC (MKF and JEG 1988)	Monitoring wells, water level contour maps.
		PMC (MKF and JEG 1989b)	Monitoring wells.
		PMC (MKF and JEG 1990a)	Geotechnical holes, piezometers.
		PMC (MKF and JEG 1991a, 1991b)	Monitoring wells.

* Refer to list of acronyms and abbreviations.

Source: MKF and JEG 1989a

2.4.2 Site-Specific Investigations

USGS 1960-1961: This investigation was performed at the request of the AEC to evaluate the hydrologic feasibility of using the quarry for waste disposal. Tests included the installation of monitoring wells, pressure testing, and pumping of the quarry sump. This investigation determined the groundwater inflow rate to the quarry and established the tightness of the bedrock below MSL (elevation 141 m [465 ft]) (Richardson 1960).

NLO 1976-1977: This investigation was performed by the National Lead Company of Ohio (NLO) to provide data to assess the actions required to protect the environment from the waste in the quarry. This investigation was the first to identify that soluble contaminants were escaping from the quarry. Monitoring-well installation, water-level monitoring, and water-quality analyses were performed (NLO 1978).

NLO 1979-1980: This study was conducted to investigate radionuclides (uranium) in fish from the Femme Osage Slough under the DOE Monitoring Program for 1979 and 1980; it was performed prior to the opening of the area as the Weldon Spring Wildlife Area in June 1980. MDOC personnel assisted the NLO with the collection of fish from the slough (NLO 1981).

LBL 1979-1981: Lawrence Berkeley Laboratory (LBL) performed a broad-based investigation of the quarry area from 1979 through 1981 (BGA 1984). This investigation included fracture mapping, air photo analysis of linears, borehole television logging, borehole geophysical logging, aquifer testing, soil sampling and analysis, groundwater modeling, a waste inventory, field and laboratory gamma spectrometry, and soil sampling and analysis. The information obtained from this investigation, particularly with respect to the hydrogeology of the study area, constitutes a substantial part of the present conceptual model (LBL 1980).

BNI 1982-1986: Bechtel National, Inc. performed numerous minor investigations in support of environmental monitoring and environmental impact statement (EIS) preparation. Efforts included installing new, and rejuvenating old, monitoring wells; performing water quality analyses; and evaluating previously collected data (BNI 1987).

Layne Western 1986: This investigation was performed by Layne Western for St. Charles County to evaluate the potential for radioactive contamination of the St. Charles County well field. Monitoring and observation wells were installed, pumping tests performed, water quality samples collected, and an electric analog model constructed during this investigation. This study provides information on the hydrogeological properties of the alluvial aquifer (Layne Western 1986).

PMC 1987-Present: The Project Management Contractor (PMC) has initiated several investigations to provide information regarding the geology of the study area, to evaluate the extent and magnitude of the contamination, and to enhance environmental monitoring efforts. These investigations have included soil and water sampling, monitoring well installation, and geotechnical testing (MKF and JEG 1988; 1989a, b; 1990a, b; 1991 a-d; 1992 a-h; 1993).

3 PHYSICAL DESCRIPTION

Section 2 of this plan presents a site description; in addition, the *Work Plan for the Remedial Investigation/Feasibility Study-Environmental Assessment for the Quarry Residuals Operable Unit at the Weldon Spring Site* (Work Plan) (ANL 1993) describes the site background and setting, climate, land use, and other physical information.

3.1 Geology

The geology in the vicinity of the Quarry Residuals Operable Unit (QROU) can be generally divided into unconsolidated surficial material and bedrock formations. Figure 3-1 is a generalized stratigraphic column for the area. Figure 3-2 is a generalized cross-section that depicts the stratigraphic relationships in the vicinity of the Weldon Spring quarry and the Femme Osage Slough.

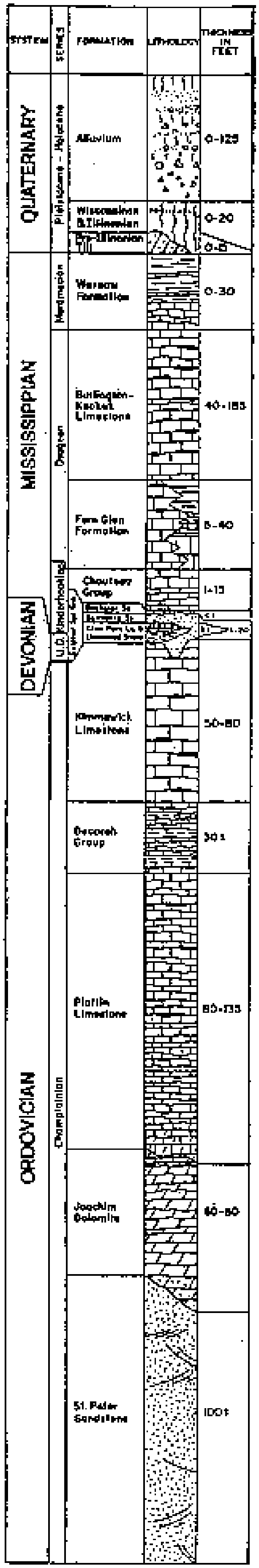
3.1.1 Unconsolidated Surficial Material

Three major types of unconsolidated surficial material are present in the QROU study area:

- Upland soils
- Tributary alluvium
- Missouri River alluvium

Upland soils are present on the bluffs formed by erosionally resistant Paleozoic bedrock units. Upland soils are found at elevations higher than the quarry pond and are typically composed of Pleistocene loess and residual material derived from the weathering of the surficial bedrock formations. Surface soils are a brown to yellow-brown silty clay loam of the Menfro-Harvestor-Welles Association (U.S. Department of Agriculture 1982). Upland material varies in thickness from 0 to 12 m (0 to 40 ft) (BGA 1984).

Tributary alluvium of the Quaternary System is found within the study area. This alluvium is located in the stream valley of the Little Femme Osage Creek, which dissects the



NOTE: MISSISSIPPIAN AND DEVONIAN ROCKS GENERALLY NOT PRESENT IN IMMEDIATE VICINITY OF QUARRY.

SOURCE: WHITFIELD ET AL. 1989

GENERALIZED STRATIGRAHIC COLUMN FOR THE WELDON SPRING QUARRY AREA

FIGURE 3-1

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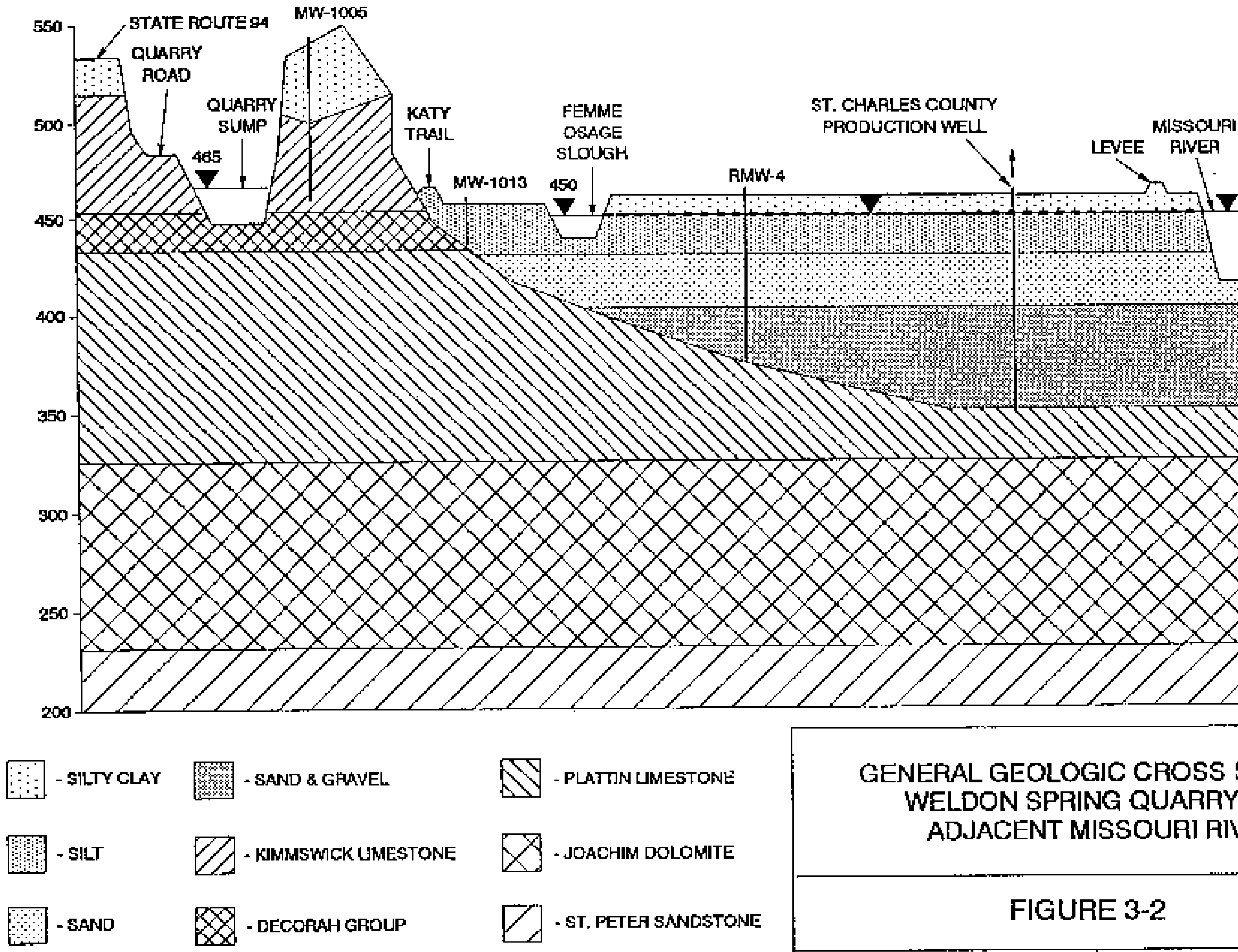

MODIFIED AFTER BGA, 1986

NOT TO SCALE

GENERAL GEOLOGIC CROSS SECTION WELDON SPRING QUARRY AND ADJACENT MISSOURI RIVER

FIGURE 3-2

REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/PI/041/0393
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upland area to the north of the quarry. These deposits may be quite gravelly in places, but where the tributary adjoins the floodplain of the Missouri River, gravelly deposits are covered by fine-textured silts and clays (Whitfield et al. 1989).

Quaternary alluvial deposits associated with the Missouri River dominate the study area to the south of the quarry. Whitfield (1989) reports that these deposits include clay, silt, sand, and gravel intermixed and interbedded. These deposits may exceed 38 m (125 ft) in thickness. The upper third is usually much finer in texture, and deposit coarseness increases with depth. The upper third of the unit typically consists of silt, sand, and lesser amounts of gravel, whereas the lower third contains cobbles and boulders.

3.1.2 Bedrock Geology

The geologic maps of the Weldon Spring and Defiance quadrangles prepared by the Missouri Department of Natural Resources-Department of Geology and Land Survey (MDNR-DGLS) (Whitfield et al. 1989) provide the best reference for the local stratigraphy and structure of the bedrock units present in the vicinity of the quarry. Additional descriptions are provided by Kleeschulte and Emmett (1987), Berkeley Geosciences Associates (1984), and MKF and JEG (1992c).

3.1.2.1 Stratigraphy. The important stratigraphic divisions in the vicinity of the quarry are primarily composed of rocks of the Ordovician System. In descending order, from youngest to oldest, these rocks include the Kimmswick Limestone, Decorah Group, Plattin Limestone, Joachim Dolomite, and St. Peter Sandstone.

The Kimmswick Limestone is the uppermost bedrock unit at the quarry and is approximately 15 to 24 m (50 to 80 ft) thick, highly fossiliferous, medium to coarsely crystalline, medium to thick bedded, and cherty near the base (Whitfield et al. 1989). The Kimmswick Limestone commonly contains stylolites along bedding planes and is susceptible to dissolution as evidenced by numerous cavities observed in outcrop and boreholes (Huey 1978).

The Kimmswick Limestone unconformably overlies the rocks of the Decorah Group. The Decorah Group is about 9 m (30 ft) thick and is composed of tan to gray, finely crystalline to lithographic, shaly limestone. It consists of thin- to medium-bedded limestones with interbedded gray, clayey, fossiliferous shales. Additionally, the unit contains several thin, 7 to

10 cm (3 to 4 in.) light-brown bentonite beds. This unit is usually poorly exposed in outcrop (Whitfield et al. 1989).

The Plattin Limestone conformably underlies the Decorah Group. The Plattin Limestone is 24 to 41 m (80 to 135 ft) thick and is composed of light- to dark-gray, finely crystalline to lithographic, thin- to medium-bedded, slightly cherty limestone. The unit also contains burrows, pitted texture, and thin platy beds 7 to 10 cm (3 to 4 in.) thick (Whitfield et al. 1989). The lower 1.5 to 3 m (5 to 10 ft) is sometimes found to be a brown dolomitic limestone which is argillaceous and fine to medium crystalline. Whitfield et al. (1989) also note the existence of enlarged solution joints in many places.

The Joachim Dolomite underlies the Plattin Limestone. The Joachim Dolomite is 18 to 24 m (60 to 80 ft) thick and varies from dolomite to calcareous dolomite. The unit is a light-brown to light gray, finely crystalline, argillaceous, silty, and thin to massively bedded. The upper portion varies from vuggy with irregular bedding to shaly (Whitfield et al. 1989).

The St. Peter Sandstone is approximately 30 m (100 ft) thick as noted by Whitfield et al. (1989). The unit is a weakly cemented, well sorted, yellow-brown, reddish-brown to brownish-white, medium- to fine-grained, well-rounded, frosted quartz sandstone of exceptional purity (Whitfield et al. 1989, Koenig 1961).

3.1.2.2 Structure. The site is near the northern extent of the Salem Plateau, a subdivision of the Ozark Plateau Physiographic Province and near the southern extent of the Dissected Till Plains of the Central Lowlands Province (Kleeschulte and Emmett 1987). Near the site, topography is characterized by the steep slopes of dissected bedrock bluffs which form the northern portion of the Missouri River Valley. Within a few kilometers to the north, the topography changes to the gentle, rolling landscape typical of the Dissected Till Plains. This physiographic transition nearly coincides with the commonly accepted southern extent of Holocene continental glaciation.

Due to vertical crustal movement during the Paleozoic Era, rocks of the central Stable Region, of which Missouri is a part, were deformed into broad basins and arches (Eardley 1962). Located about 6 km (4 mi) west of the site is the northwest trending axis of the Eureka-House Springs anticline (BNI 1987). Rocks on the northeast limb of this gentle fold strike approximately N60W and dip approximately 0.5° to 1° to the northeast. Approximately 7 km

(4.3 mi) to the northeast an unnamed east-trending normal fault is present. This fault reportedly exhibits about 18 m (60 ft) of vertical displacement with the north block down (Whitfield et al. 1989).

The site lies within the techtonically quiet, central stable seismic region. The New Madrid seismic zone at the northern end of the Mississippi Embayment, located about 260 km (160 mi) south of the site, is the nearest zone of major seismic activity (BNI 1983). No evidence has been found of tectonic surface ruptures related to historic earthquakes in the area (MKF and JEG 1992d).

A fracture-mapping program conducted by Lawrence Berkeley Laboratory (LBL) (BGA 1984) determined a dominant vertical fracture orientation of N70W with an average spacing of 9 m (30 ft). Minor fracture sets were also found to be vertical, with orientations of N60E and N-S. LBL also identified potential conduits for fluid flow in the Kimmswick Limestone. Most joints in the quarry wall were found to be open with apertures that varied from 2.5 cm (1 in.) to greater than a meter. Clay fillings are present in many of the joints. Closely spaced joints and fractures were observed in areas associated with gullies in the bluffs and probably represent zones of more intense weathering and solution activity associated with upland drainage. The joint surfaces along the bluffs and on the quarry walls are typically etched, suggesting that these surfaces have been in contact with groundwater at some time (BGA 1984).

3.2 Hydrogeology

The hydrogeology of the quarry area occurs in three primary domains: alluvium; fractured limestone, dolomite, and shale; and the St. Peter Sandstone (BGA 1984). Additionally, unsaturated upland soils, the quarry pond, Femme Osage Slough, Little Femme Osage Slough, and the Missouri River all affect the hydrogeological characteristics of the area. The following sections briefly describe the important groundwater and surface water characteristics of the study area. Additional information is provided in Kleeschulte and Emmett (1987).

3.2.1 Alluvium and Upland Soils

Saturated conditions within Missouri River alluvium are generally encountered within the upper 3 m (10 ft). South of the Femme Osage Slough, groundwater is extracted from the alluvium by St. Charles County from eight production wells. These production wells produce 90,850 m^3/d (24 mgd) at peak demand (ANL 1990). In the vicinity of the well field, pumping rates as well as river stages affect water levels.

Upland soils are topographically higher than the quarry pond, which is the primary contaminant source in the vicinity. Upland soils are generally not saturated and are not thought to host substantial sources of contamination; however, upland soils do influence annual recharge to waterbearing portions of the bedrock in areas where infiltration occurs.

The hydraulic properties of the alluvial aquifer are highly variable, depending on the thickness and dominant grain size of the material at a given location. The material north of the Femme Osage Slough possesses substantially different hydraulic properties than the material to the south. Development of observation wells installed north of the slough by LBL involved extended recovery periods following pumping (BGA 1984). Pumping tests, tracer tests and a point dilution test were conducted in the alluvium south of the slough (BGA 1984). Test results are listed in Table 3-1.

TABLE 3-1 Hydraulic Properties Estimated from Aquifer Tests Performed in the Alluvium South of Femme Osage Slough

Statistics	Transmissivity (m^2/s)	Storativity	Effective Porosity[a]
Minimum	1.2×10^{-6}	1.5×10^{-4}	0.25
Maximum	1.0×10^{-3}	1.9×10^{-2}	0.32
Average	1.3×10^{-3}	7.9×10^{-3}	--
Standard deviation	1.4×10^{-3}	1.0×10^{-2}	--

[a] Average and standard deviation values were not calculated for effective porosity because of limited data.

Values calculated by ANL (1993) on the basis of data from Berkeley Geosciences Association (1984).

The groundwater flow potential from the southern portion of the quarry toward the Femme Osage Slough has been well established. Groundwater levels in the alluvium near the slough measure about 3 m (10 ft) lower than groundwater levels in the bedrock near the south rim of the quarry. Groundwater flow south of the slough is affected by pumping and river stage.

The relationship between the slough and groundwater levels is also variable. At low river stages, the slough may act as a drain for groundwater; at other times, groundwater in the slough vicinity may be virtually stagnant or may flow southeast beneath the slough. Recent drought conditions demonstrated isolation of the slough from vicinity groundwater, as groundwater levels south of the slough were 1.5 to 2.4 m (5 to 8 ft) lower than water within the slough (MKF and JEG 1988).

3.2.2 Bedrock Hydrogeology

Near-surface groundwater occurs in the Kimmswick Limestone, Decorah Group, and Plattin Limestone. This groundwater is in hydraulic connection with the quarry pond. Porosity in the carbonate bedrock is primarily a function of fractures, joints, bedding planes and solution-enhanced cavities, and discontinuities. Studies conducted by Richardson (1960), Huey (1978), and BGA (1984) confirm that groundwater movement is governed by secondary porosity in the form of joints and fractures in the Upper Ordovician units near the quarry. BGA (1984) found that solution-enlarged cavities occur in the near-surface weathered portions of the Kimmswick Limestone, but these features generally occur above the present groundwater table. Intergranular porosity within the carbonate formations can essentially be ignored with respect to groundwater flow and transport of contaminants, due to the lithographic nature of the rock.

Regionally, the Decorah Group is considered to be a leaky confining layer due to shale beds (Kleeschulte and Emmett 1986). However, a fracture-mapping program performed by LBL between 1979 and 1981 concluded that fracture patterns observed at the surface in the Kimmswick Limestone extend vertically through the Decorah Group (BGA 1984). This information, along with the knowledge that the quarry was excavated about 15 ft into the Decorah Group, suggests that locally the Kimmswick and Decorah units may be considered to be one hydrostratigraphic unit in the residuals area.

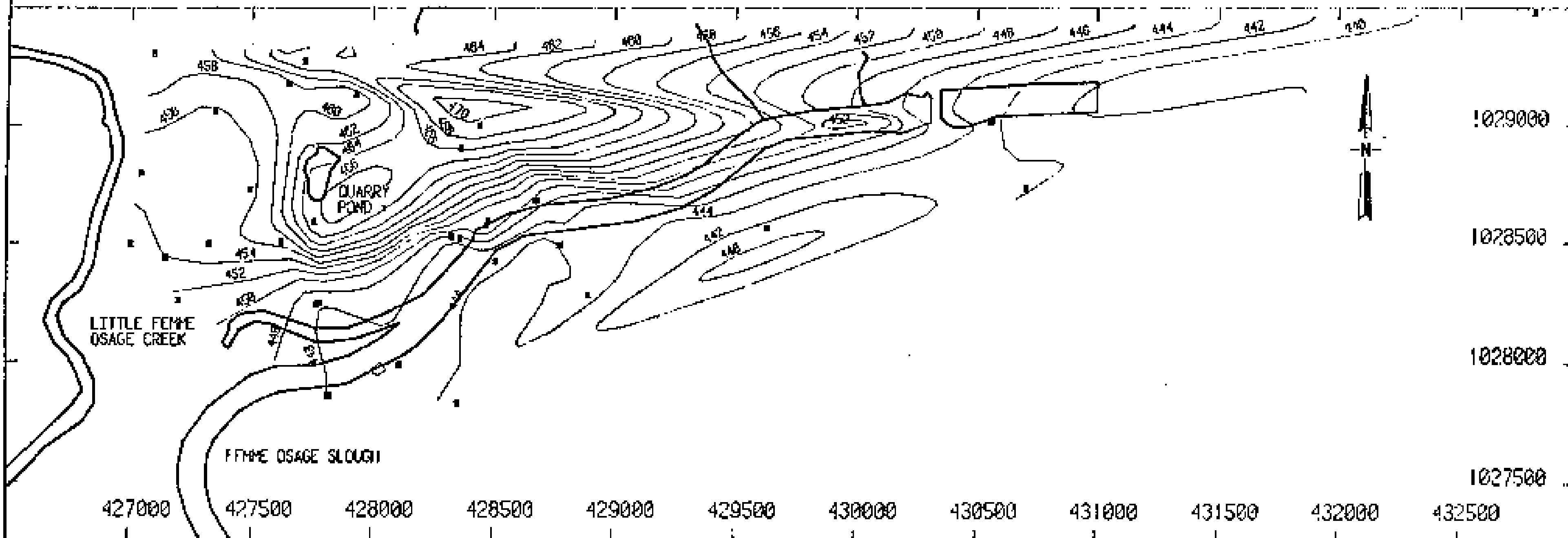
From vertical core logging performed in 1991, the Plattin Limestone appears massive with very little evidence of fracturing. Presently, water levels within the Plattin do not appear to correlate with the fracture system in the Kimmswick-Decorah units; therefore, the Plattin is considered as a separate hydrostratigraphic unit. In a regional sense, the Plattin Limestone and

Joachim Dolomite constitute the lower portions of the leaky confining layer (Ordovician) as described by Kleeschulte and Emmett (1987), and wells completed in these units may yield small quantities of water 38-189 l/m (10-50 gpm) on a local basis.

The St. Peter Sandstone is the uppermost bedrock aquifer of regional significance beneath the quarry. This formation is the youngest unit within the deep bedrock aquifer (Ordovician-Cambrian) as described by Kleeschulte and Emmett (1987). The upper contact for the St. Peter Sandstone may be as deep as 76.2 m (250 ft) in the area of the quarry. Potentiometric conditions within the deep bedrock aquifer have been evaluated by Kleeschulte and Emmett (1986, 1987). This evaluation indicates that the potentiometric head in the St. Peter Sandstone is approximately 460 ft MSL. This elevation is just below that of the quarry pond prior to dewatering (465 ft MSL). Flow within the St. Peter Sandstone near the quarry is generally south toward the Missouri River; however, about 6.4 km (4 mi) southwest of the quarry, the Femme Osage Creek is a local discharge point for deep groundwater where the St. Peter Sandstone is exposed at the land surface. Withdrawals from this aquifer for drinking purposes occur in the O'Fallon, Missouri, area approximately 16 km (10 mi) north-northeast of the quarry. The vulnerability of the deep bedrock aquifer to contamination from wastes contained in the quarry prior to bulk waste removal and residual sources is considered extremely remote due to the thick sequence of intervening confining formations and the strong upward hydraulic gradient present within the deep bedrock aquifer.

In the immediate vicinity of the quarry, details of groundwater flow in the bedrock have not been completely defined. Groundwater level information analyzed by Richardson (1960) and LBL (BGA 1984) concluded that flow in the upper bedrock was from north to south.

Figure 3-3 depicts the average shallow groundwater surface elevation for 1990 and 1991. Figure 3-4 depicts the shallow groundwater surface for May 1990 when monthly precipitation exceeded 25 cm (10 in.). Figure 3-5 is a difference map generated from Figures 3-3 and 3-4. These maps illustrate general variations in the potentiometric surface due to seasonal influences. The change in groundwater elevations south of the quarry pond and north of the Femme Osage Slough indicates differences in hydraulic properties associated with the bedrock and marginal alluvium.



▪ MONITORING WELLS

CONTOUR INTERVAL = 2 FT.

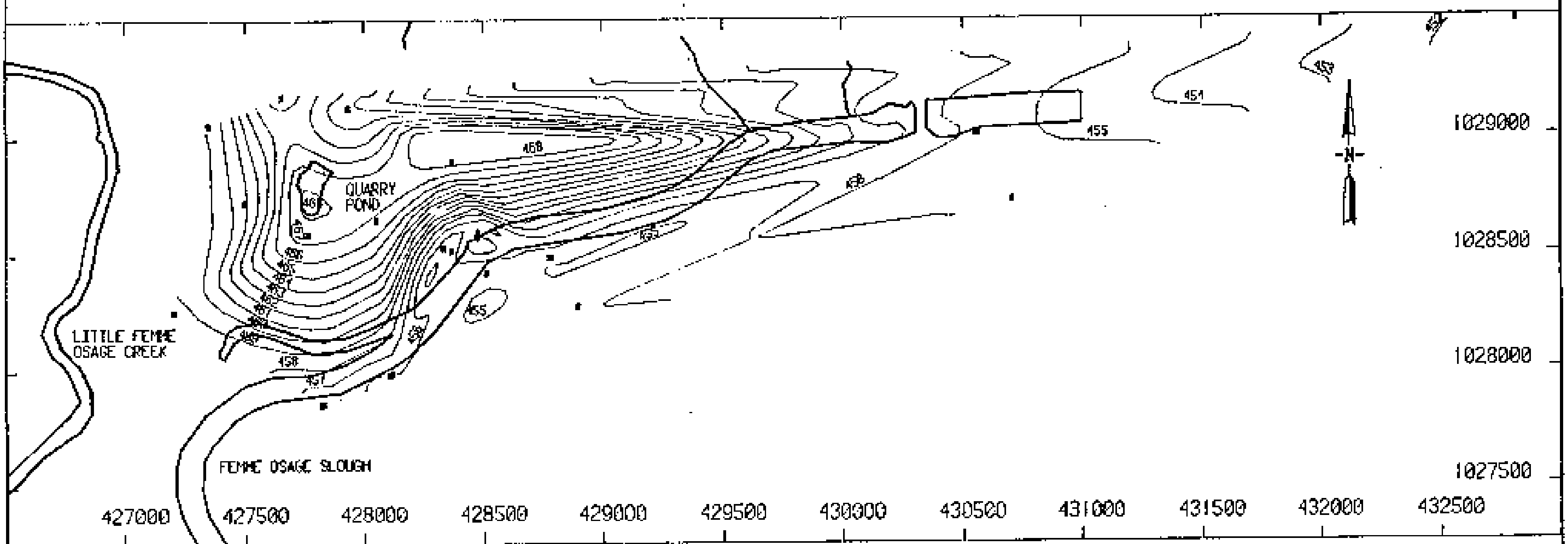
100 50 0 100 200 300 400 METERS

200 100 0 200 400 600 800 FEET

AVERAGE SHALLOW GROUNDWATER SURFACE ELEVATION FOR 1990 - 1991

FIG. 3-3

REPORT NO: DOE/OR/21548-382		EXHIBIT NO: A/QY/041/0493
ORIGINATOR: JDC	DRAWN BY: WSSRAP GIS	DATE: 03/93



▪ MONITORING WELLS

CONTOUR INTERVAL = 2 FT.

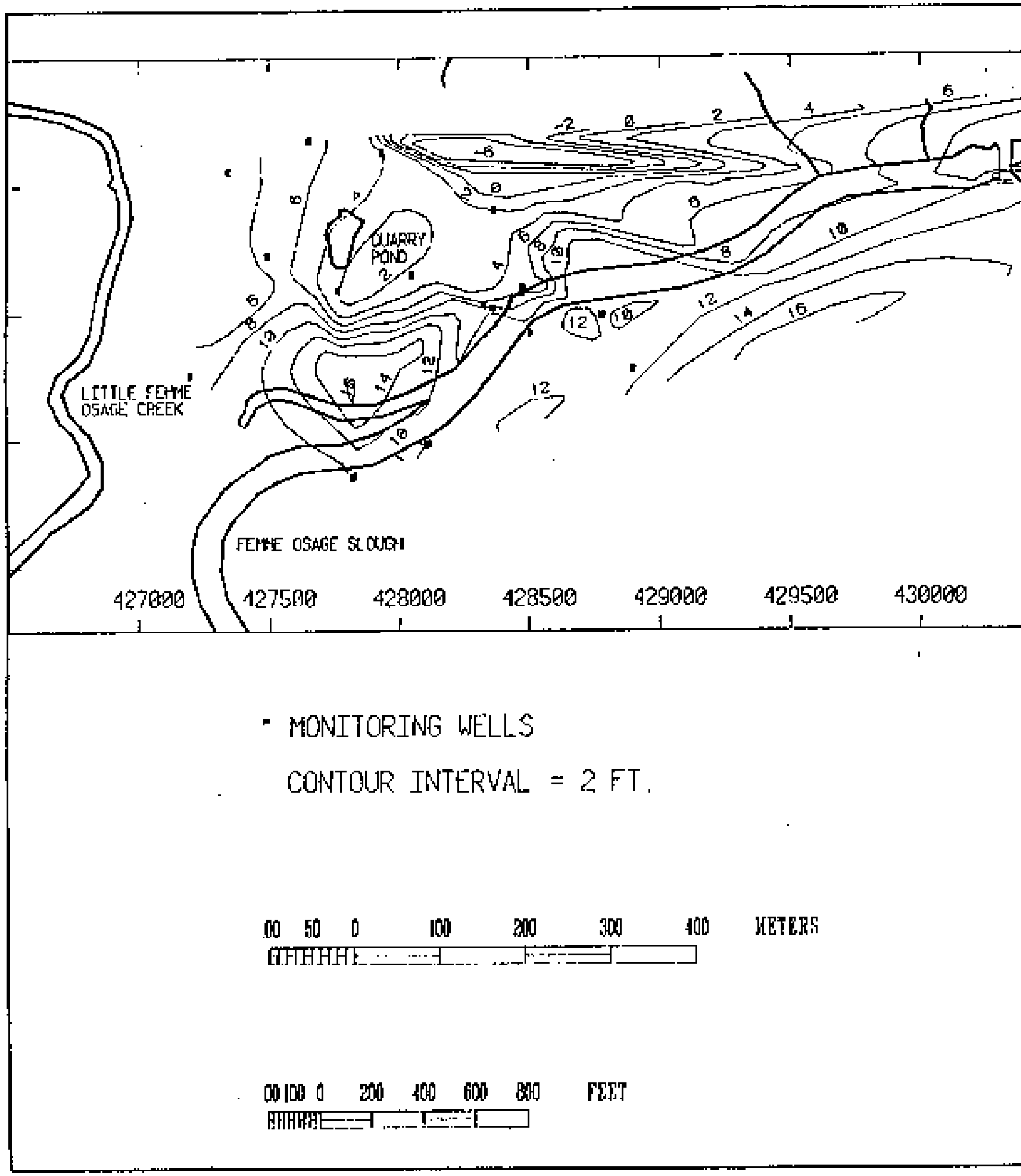
00 50 0 100 200 300 400 METERS

00 100 0 200 400 600 800 FEET

SHALLOW GROUNDWATER SURFACE ELEVATION FOR 5/29/90

FIG. 3-4

REPORT NO: DOE/OR/21548-382		EXHIBIT NO: A/QY/042/0493	
ORIGINATOR: JDC	DRAWN BY: WSSRAP GIS	DATE: 03/93	



GROUNDWATER SURFACE ELEVATION DIFFERENCE BETWEEN 5/29/90 AND AVERAGE FOR 1990 AND 1991

FIG. 3-5

REPORT NO: DOE/OR/21548-382		EXHIBIT NO: **A/QY/043/0493**
ORIGINATOR: JDC	DRAWN BY: WSSRAP GIS	DATE: 03/93

Pumping tests performed in the quarry by Richardson (1960) provided early evidence of the hydraulic connection between the pond and the Kimmswick Limestone and Decorah Group, the nature of the groundwater gradient from the quarry to the Missouri River alluvium, and the potential for migration of contaminants from the quarry to the alluvium.

Richardson also conducted limited pressure testing of observation wells. The results demonstrated a decrease in permeability with increasing depth. These tests were conducted in the lower 9 m (30 ft) of the Kimmswick Limestone and the upper 9 m (30 ft) of the Decorah Group.

LBL conducted pumping tests, a point dilution test, and a convergent flow tracer test in wells completed in the upper portion of the Plattin Limestone. Testing may also have included a portion of the lower Decorah Group. The results of these tests are presented in Table 3-2. These tests characterize the bedrock below the alluvium as a fracture flow system with predominantly horizontal flow paths (MKF and JEG 1989a).

TABLE 3-2 Hydraulic Properties Estimated from Aquifer Tests Performed in the Lower Decorah Group/Upper Plattin Limestone

Statistics	Transmissivity (m^2/s)	Storativity	Effective Porosity[a]
Minimum	3.7×10^{-6}	6.7×10^{-5}	0.001
Maximum	2.0×10^{-4}	3.8×10^{-3}	0.002
Average	4.9×10^{-5}	6.4×10^{-4}	--
Standard deviation	5.5×10^{-5}	1.3×10^{-3}	--

[a] Average and standard deviation values were not calculated for effective porosity because of limited data.

Values calculated by ANL (1993) on the basis of data from Berkeley Geosciences Association (1984).

3.3 Ecology

3.3.1 Flora

The quarry is located in the Bluestem Prairie Oak-Hickory Forest Mosaic subsection of the Prairie Parkland Province (Bailey 1978). This area is characterized by dense to open riparian woodlands interspersed with upland prairie. Today, much of the prairie has been converted to agricultural fields, and remnants of the prairie in the state are rare (Missouri Botanical Garden). There are no prairie habitats within the QROU area. Most of the land around the quarry is State-owned property, including the 7,230-acre Weldon Spring Wildlife Area. This area is actively managed for wildlife and includes various habitats such as forest, streams, and agricultural fields (ANL 1990).

The quarry is primarily forest, with some old-field habitat. The quarry rim and surrounding area are primarily slope forest and bottomland forest. A portion of the natural bluff, with an elevation of 100 ft, separates the quarry rim and pond from the Missouri River and floodplain located to the east. Slope forests located along the bluff include deciduous trees such as oaks and hickories.

Disturbed roadside habitat is found along the Katy Trail adjacent to the quarry. In the floodplain area, agricultural fields are maintained by the Missouri Department of Conservation (MDOC) under share-cropping agreements with portions left in the fields for use as wildlife forage areas. Corn, soybeans, and milo are primarily planted in these fields.

Numerous aquatic habitats exist throughout the Weldon Spring Wildlife Area and in the immediate vicinity of the quarry. These include the Missouri River, the Little Femme Osage Creek, the Femme Osage Creek, the Femme Osage Slough, and numerous small unnamed creeks, drainages, and ponds throughout the area. Bottomland forests occur along the aquatic habitats and their drainageways and include tree species such as eastern cottonwood and sycamore. Periodic flooding and fluctuations in the water level are also characteristic of these areas and maintain the growth of flood tolerant species such as silver maples (*Acer saccharinum*) and willows. A detailed description of ecological resources in the vicinity of the QROU is presented in the Work Plan.

3.3.2 Fauna

Fauna in the area surrounding the Weldon Spring quarry is rich and diverse. The area is capable of supporting a variety of animals common to deciduous forests, agricultural areas, and aquatic habitats. The Weldon Spring Wildlife Area is also actively managed by the MDOC to maintain the natural resources within the area.

The MDOC reports 25 amphibian, 47 reptilian, 29 mammalian, and 299 avian species in St. Charles County (Dickneite 1988). Many of the terrestrial vertebrates found within this area are widely distributed species. Species that have been observed within the quarry pond area include squirrels, raccoons, and deer mice. The surrounding area is managed for game species such as the white-tailed deer, dove, and rabbit. Skinks and three-toed box turtles are found among vegetation in the slope forest floor.

Aquatic habitats within the quarry area are also known to support a variety of fauna. Waterfowl such as wood ducks and Canada geese have been sighted at the Femme Osage Slough. Reptiles such as the red-eared slider, and soft-shelled turtle are found basking on logs and debris within the slough. The MDOC has recorded more than 105 species of fish in St. Charles County (Dickneite 1988). Fish surveys of the Femme Osage Slough have recorded species including carp, channel catfish, buffalo, gar, sunfish, crappie, and a variety of minnows and shiners (MDOC 1991a).

3.3.3 Special Concern Populations and Habitats

3.3.3.1 Threatened and Endangered Species. Several species classified as rare or endangered are known to occur in St. Charles County and are listed in Table 3-3. No designated critical habitat for these species is known to exist at the quarry (Haroun et al. 1991). The nearby Howell Island Wildlife Area south of the quarry provides an important night roost for overwintering bald eagles (a Federally endangered species). The pallid sturgeon (*Scaphirhynchus albus*), a Federally endangered species, has been reported in the Missouri River near the Weldon Spring site. Two Federal Category 2 fish species have been recorded in the Missouri River downstream of the quarry: sturgeon chub (*Macrhybopsis gelida*) and sicklefin chub (*Macrhybopsis meeki*).

TABLE 3-3 Threatened, Endangered, or Special-Concern Species Reported from St. Charles County

Species			
Common Name	**Scientific Name**	**Federal**[a]	**State**[b]
Plants			
Adder's-tongue fern	*Ophioglossum vulgatum var. pycnostichum*	-	WL
Arrow arum	*Peltandra virginica*	-	R
Bugseed	*Corispermum hyssopifolium*	-	WL
Rose turtlehead	*Chelone oblique var. speciosa*	3C	E
Star duckweed	*Lemna trisulca*	-	R
Decurrent false aster	*Boltonia decurrens*	T	E
Fish			
Alabama shad	*Alosa alabamae*	-	R
Alligator gar	*Lepisosteus spatula*	-	R
Brown bullhead	*Ameiurus nebulosus*	-	R
Paddlefish	*Polyodon spathula*	C2	WL
Pallid sturgeon	*Scaphirhynchus albus*	E	E
Pugnose minnow	*Notropis emiliae*	-	WL
Sicklefin chub	*Macrhybopsis meeki*	C2	R
Starhead topminnow	*Fundulus dispar*	-	WL
Sturgeon chub	*Macrhybopsis gelida*	C2	R
Western sand darter	*Ammocrypta clara*	-	WR
Reptiles and amphibians			
Alligator snapping turtle	*Macroclemys temminckii*	C2	R
Blanding's turtle	*Emydoidea blandingii*	-	E
Eastern massasauga	*Sistrurus catenatus catenatus*	C2	E
Northern crawfish frog	*Rana areolata circulosa*	-	WL
Western fox snake	*Elaphe vulpina vulpina*	-	E
Western smooth green snake	*Opheodrys vernalis blanchardi*	-	E
Wood frog[+]	*Rana sylvatica*	-	R
Mammals			
Long-tailed weasel	*Mustela frenata*	-	R
Birds			
American bittern	*Botaurus lentiginosus*	-	E
Bachman's sparrow	*Aimophila aestivalis*	C2	E
Bald eagle[+]	*Haliaeetus leucocephalus*	E	E
Barn owl	*Tyto alba*	-	R
Black-crowned night heron	*Nycticorax nycticorax*	-	R
Cooper's hawk	*Accipiter cooperii*	-	R
Henslow's sparrow	*Ammodramus henslowii*	C2	R
Interior least tern	*Sterna antillarum athalassos*	E	E
Little blue heron	*Egretta caerulea*	-	R
Mississippi kite	*Ictinia mississippiensis*	-	R
Northern harrier[+]	*Circus cyaneus*	-	E
Osprey	*Pandion haliaetus*	-	EX
Peregrine falcon	*Falco peregrinus*	E	EX
Pied-billed grebe	*Podilymbus podiceps*	-	R
Red-shouldered hawk	*Buteo lineatus*	-	WL
Loggerhead shrike[+]	*Lanius ludovicianus*	C2	WL

TABLE 3-3 Threatened, Endangered, or Special-Concern Species Reported from St. Charles County (Continued)

Species			
Common Name	Scientific Name	Federal[a]	State[b]
Birds (Continued)			
Sharp-shinned hawk	*Accipiter striatus*	-	R
Snowy egret	*Egretta thula*	-	E
Upland sandpiper	*Bartramia longicauda*	-	WL
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	-	R
Swainson's hawk[+]	*Buteo swainsoni*	3C	E

[a] E, endangered; T, threatened; C2, federal candidate for listing as a threatened or endangered species; 3C, former federal candidate species. A hyphen indicates that no federal status has been established.

[b] E, endangered; EX, extirpated; R, rare; U, undetermined; WL, watch list. Special-concern species include those classified by the state as rare, on the watch list, or of undetermined status. Watch list contains species of possible concern for which the Missouri Department of Conservation is seeking further information; this listing does not imply that these species are imperiled. Undetermined indicates that the species is possibly rare or endangered, but insufficient information is available to determine the proper status. Extirpated means formerly occurred as a regular breeding species but no longer reproduces in Missouri.

[+] Individuals have been observed within the Quarry Residuals Area.

Sources: Dickneite (1988); Gaines (1988); Sedan (1991); Figg (1991).

The MDOC reports 15 State endangered, 17 State rare, and 10 State "special-concern" species within St. Charles County (Gaines 1988; MDOC 1991b). Of these species, the Cooper's hawk (*Accipiter cooperii*) and wood frog (*Rana sylvatica*), State rare species, have been reported at the Weldon Spring Wildlife Area. The wood frog has been observed at the quarry pond and within deciduous forests to the north of the quarry (Johnson 1991). The northern harrier (*Circus cyaneus*), loggerhead shrike (*Lanius ludovicianus*), Swainson's hawk (*Buteo swainsonii*), and bald eagle (*Haliaeetus leucocephalus*) have all been observed at various times within the Weldon Spring Wildlife Area. The Blanding's turtle (*Emydoidea blandingii*), a state endangered reptile, was recently sighted at the Busch Wildlife Area. The preferred habitat includes marshes, lakes, and small streams. The status of the Blandings turtle in the QROU is not known.

3.3.3.2 High Quality Habitat. The MDOC has identified four high-quality natural communities in the area of the Weldon Spring site (Gaines 1988). These communities include a mesic forest and a dry-mesic chert forest located in the Weldon Spring Wildlife Area south of State Route 94 near the chemical plant, and a very high-quality chert forest and a chert savannah located northwest of the quarry. These communities are not contiguous with the QROU area.

3.3.3.3 Wetlands. The following aquatic habitats near the Weldon Spring Quarry have been designated as wetlands on the U.S. Fish and Wildlife Service *National Wetlands Inventory Map* (FWS 1989): the Femme Osage Slough, Little Femme Osage Creek, Femme Osage Creek, and the Missouri River. These areas are subject to Section 404 of the Clean Water Act in which protection of wetland areas is required under Federal law. According to Federal guidance developed to make jurisdictional wetland determinations, three conditions must be met: the presence of hydric soils, saturated soil conditions for at least seven days during the growing season, and presence of hydrophytic vegetation (FICWD 1989). While the slough was part of the Little Femme Osage Creek and the Femme Osage Creek systems until being dammed in the 1950s by the University of Missouri, it is classified as a man-made impoundment, this status does not exclude a requirement for a wetlands determination or delineation.

4 ACTIVE ENVIRONMENTAL INVESTIGATIONS

Environmental monitoring, surveillance, and characterization activities are conducted at the quarry as required to comply with regulatory requirements and U.S. Department of Energy (DOE) environmental protection policies established by DOE Order 5400.1 and to ensure the protection of the public.

Two types of information are collected and evaluated during environmental monitoring activities: documentation (e.g., field notes, data quality reviews) and analytical data. The information collected provides data to evaluate remedial efforts, public and worker safety, and environmental protection.

All phases of data collection, analysis, and quality; guidance for developing data quality objectives (DQOs) according to U.S. Environmental Protection Agency (EPA) Guidelines; and data quality requirements (DQRs) are addressed within the *Environmental Data Administration Plan* (EDAP) (MKF and JEG 1992a). This includes sampling-plan preparation, data verification and validation, database administration, and data archiving. The DQRs identify specific goals that include precision, accuracy, and completeness and are standard in their application for environmental monitoring. The EDAP is directed by the *Environmental Quality Assurance Project Plan* (EQAPjP) (MKF and JEG 1992).

Standard Operating Procedures (SOPs) have been developed to provide consistency in sample-collection methodology and documentation of environmental activities. The SOPs include procedures for the collection, identification, preservation, and shipment of samples and for data quality review. They are issued as controlled copies, reviewed annually, and updated as necessary to incorporate changes.

4.1 Environmental Monitoring Plan

Environmental surveillance activities, which include monitoring of surface water, groundwater, radon, gamma exposure, air particulate, sediment, and meteorological conditions, are updated yearly in the *Environmental Monitoring Plan for Calendar Year 1993* (MKF and JEG 1992b). This plan describes the applicable monitoring requirements, analytical methods, quality assurance measures, and details and rationale for sampling frequencies and analytical parameters.

The 1993 surveillance activities include the sampling of 13 surface water locations within or near the quarry; samples from the Missouri River, the Femme Osage Slough, the Femme Osage Creek, and the Little Femme Osage Creek are collected routinely. All locations are monitored bimonthly for total uranium and at least annually for arsenic, barium, nitrate, sulfate, nitroaromatic compounds, Th-228, Th-230, Th-232, Ra-226, Ra-228, gross alpha, and gross beta.

The groundwater is monitored by a program designed to address applicable regulations and standards, public concerns, and potential or actual impacts on human health and the environment. Characterization has been provided through the implementation of plans that were approved by the DOE and the EPA and include sampling locations, procedures, equipment, frequency and analysis requirements, minimum detection limits, and levels of quality assurance/quality control. Currently there are 34 wells, including eight municipal production wells, four county-owned monitoring wells, and 22 DOE monitoring wells, which are screened within the alluvial material between the quarry and the Missouri River. There are also 14 DOE monitoring wells screened within the Kimmswick-Decorah or Plattin Formations to monitor contaminants within the bedrock near the quarry. Three separate monitoring programs have been developed for the quarry, each designed to monitor specific areas according to the levels of contaminant impact, public concern, and regulatory guidelines. Tables 4-1, 4-2, and 4-3 summarize groundwater monitoring efforts.

The rationale for these monitoring efforts is not only to ensure protection of public health and the environment but also to provide information on the effects of quarry de-watering and bulk waste removal. Spatial and temporal trend analyses are performed as part of monitoring data analysis (MKF and JEG 1992b). The rationale for baseline geochemical analyses is to provide information to assist in interpretation of the interaction of groundwater with contaminants and the surrounding environment as well as to evaluate potential contaminant transport mechanisms (especially across the Femme Osage Slough) for the Quarry Residuals Operable Unit (QROU) (MKF and JEG 1992b). These activities also support characterization efforts.

TABLE 4-1 Weldon Spring Quarry Groundwater Monitoring Program Summary for 1993

	Total Uranium	Radiological Parameters	Nitroaromatics	Sulfate	Geochemical
MW-1002	M	A	M	M	Q
MW-1004	M	A	M	M	-
MW-1005	M	A	M	M	Q
MW-1006	B	A	B	B	-
MW-1007	B	A	B	B	-
MW-1008	B	A	B	B	-
MW-1009	B	A	B	B	-
MW-1010	Q	A	Q	Q	-
MW-1011	Q	A	Q	Q	-
MW-1012	B	A	B	B	-
MW-1013	B	A	B	B	Q
MW-1014	B	A	B	B	Q
MW-1015	B	A	B	B	-
MW-1016	B	A	B	B	-
MW-1017	B	A	Q	Q	-
MW-1018	B	A	Q	Q	Q
MW-1019	B	A	Q	Q	Q
MW-1020	B	A	Q	Q	-
MW-1021	B	A	Q	Q	Q
MW-1022	B	A	Q	Q	Q
MW-1023	B	A	Q	Q	-
MW-1024	Q	Q*	Q	Q	-
MW-1026	B	A	B	B	-
MW-1027	M	A	M	M	-
MW-1028	B	A	B	B	Q
MW-1029	B	A	B	B	-
MW-1030	M	A	M	M	-
MW-1031	B	A	B	B	Q

TABLE 4-1 Weldon Spring Quarry Groundwater Monitoring Program Summary for 1993 (Continued)

	Total Uranium	Radiological Parameters	Nitroaromatics	Sulfate	Geochemical
MW-1032	B	A	B	B	Q
MW-1033	B	A	Q	Q	Q
MW-1034	B	A	B	B	Q

*	Gross α only quarterly
A	Annually
B	Bimonthly
M	Monthly
Q	Quarterly
SA	Semi-annually
Radiological	Gross alpha, gross beta, Th-228, Th-230, Th-232, Ra-226, and Ra-228
Geochemical	Al, As, Ba, Be, Br, Ca, Cd, Cl, Cr, Co, Cu, F, Fe, Pb, Li, Mg, Mn, Hg, Mo, Ni, P, K, Se, Ag, Na, Sr, Sb, TL, V, Zn, Fe^{+2}, NO_2, NO_3, SiO_2, sulfide, alkalinity, TDS, TOC, TSS

Source: MKF and JEG 1992b

4.2 Supplemental Environmental Monitoring Investigations

In support of environmental monitoring activities, under DOE 5400.1, the *Weldon Spring Quarry Supplementary Environmental Monitoring Investigations Sampling Plan* (SMP) (MKF and JEG 1992c) was prepared to assist in assessing the extent of contamination. Activities include shallow seismic and geophysical surveying to determine the bedrock surface underneath the Missouri River alluvium between drill holes, in-situ groundwater sampling to determine three-dimensional distribution of contaminants, and installation of wells for additional groundwater monitoring.

Briefly, the geophysical program proposed as part of the supplemental plan includes both surface and subsurface techniques. Of primary interest to the QROU effort are:

- An electromagnetic survey to assist with the delineation of plume geometry within the Missouri River alluvium.

TABLE 4-2 St. Charles County Well Field Sampling Program Summary for 1993

Monitoring Locations	Parameters											
	Total Uranium	Radiological	Nitroaromatics	Metals			Anions		Organic, VOA, SNA	PCBs Pesticides	Geochemical	Gross α
				As	Ba	Hg, Pb, Cd	Nitrate	Sulfate				
MW-1024	Q	A	Q	Q	Q	-	Q	Q	A	A	-	Q
RMW-1	Q	A	Q	Q	Q	-	Q	Q	A	A	Q	Q
RMW-2	Q	A	Q	Q	Q	-	Q	Q	A	A	Q	Q
RMW-3	Q	A	Q	Q	Q	-	Q	Q	A	A	-	Q
RMW-4	Q	A	Q	Q	Q	-	Q	Q	A	A	-	Q
PW-2	Q	A	Q	Q	Q	A	A	A	A	A	Q	Q
PW-3	Q	A	Q	Q	Q	A	A	A	A	A	-	Q
PW-4	Q	A	Q	Q	Q	A	A	A	A	A	-	Q
PW-5	Q	A	Q	Q	Q	A	A	A	A	A	-	Q
PW 6	Q	A	Q	Q	Q	A	A	A	A	A	-	Q
PW-7	Q	A	Q	Q	Q	A	A	A	A	A	-	Q
PW-8	Q	A	Q	Q	Q	A	A	A	A	A	-	Q
PW-9	Q	A	Q	Q	Q	A	A	A	A	A	Q	Q
Raw water	Q	A	Q	Q	Q	A	A	A	A	A	-	Q
Treated water	Q	A	Q	Q	Q	A	A	A	A	A	-	Q

A — Annual
M — Monthly
Radiological — Gross beta, Th-228, Th-230, Th-232, Ra-226, and Ra-228
B — Bimonthly
Q — Quarterly
Geochemical — Refer to Table 3-3

Source: MKF and JEG 1992b

TABLE 4-3 Weldon Spring Quarry Water Treatment Plant Groundwater Monitoring Program Summary for 1993

Monitoring Locations	Parameters							
	Total Uranium	Radiological	Anions	Metals	Nitroaromatics	PCBs	PAH	Pesticides
MW-1035	Q	A	Q	A	Q	A	A	A
MW-1036	Q	A	Q	A	Q	A	A	A
MW-1037	Q	A	Q	A	Q	A	A	A
MW-1038	Q	A	Q	A	Q	A	A	A
MW-1039	Q	A	Q	A	Q	A	A	A

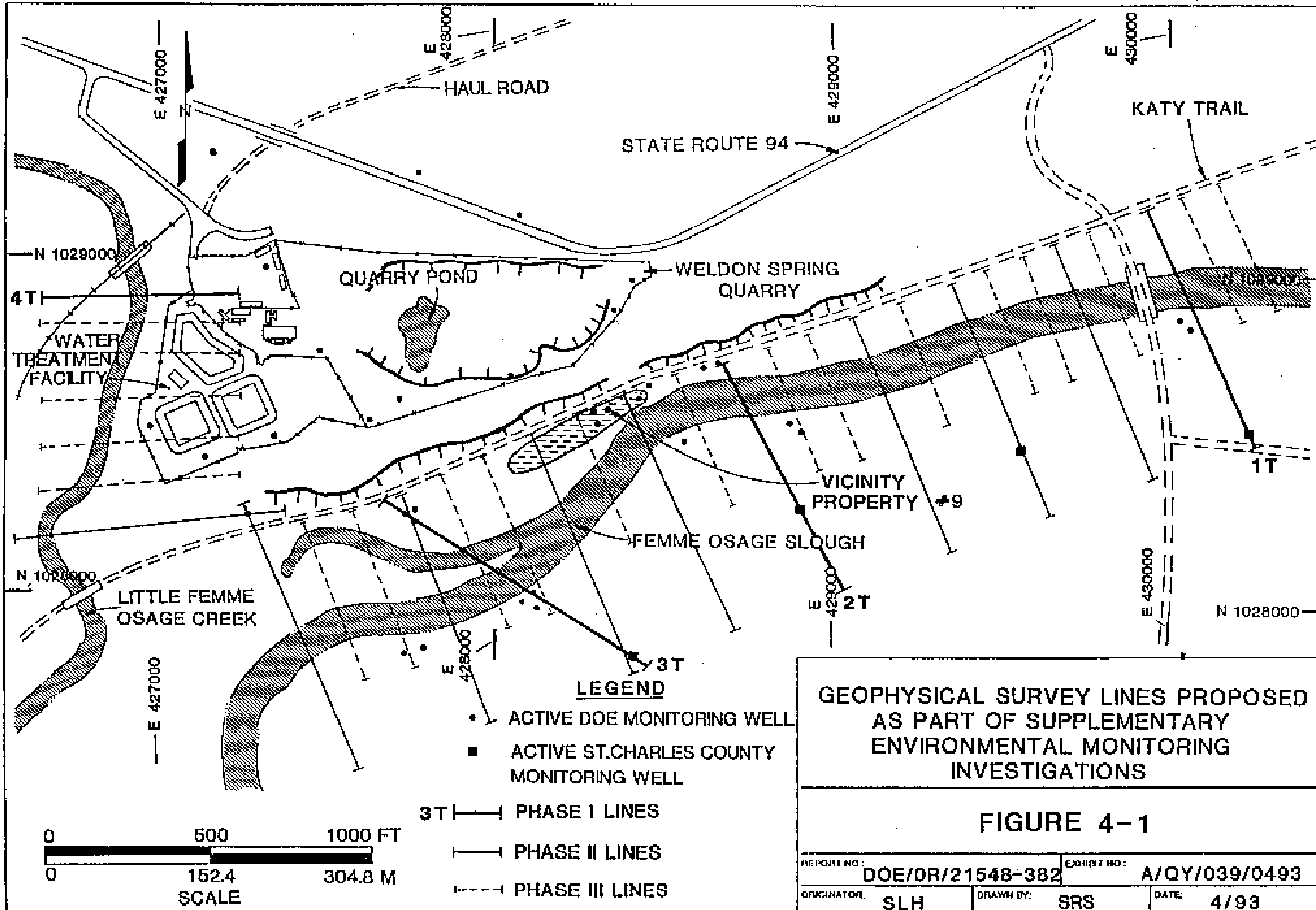
A Annually
Q Quarterly
Radiological U-238, Th-230, Th-232, Ra-226, Ra-228
Anions Nitrate and sulfate
Metals As, Ba, Cd, Pb, Cr, Hg, Se, Ag, Mg
PCBs Polychlorinated biphenyls
PAH Polynuclear aromatics (SW846 Method 8100)
Pesticides Endrin; lindane; methoxychlor; toxaphene; 2,4-D; 2,4,5-TP silvex

Source: MKF and JEG 1992b

- Shallow seismic refraction to define hydro-lithologic relationships between alluvium and bedrock to the south and west of the quarry.

Figure 4-1 shows the geophysical survey locations. The investigation will rely on a phased approach. Phase I will determine the feasibility of the proposed techniques relative to the investigation objectives, and Phases II and III will obtain progressively more detailed information as conditions allow.

In situ, or discrete, groundwater samples will be taken at the 35 locations shown in Figure 4-2. Approximately 200 discrete samples are planned. These one-time samples will be collected from specific points, without installing permanent wells, in an attempt to better define contaminant boundaries for uranium, nitroaromatics, arsenic, and sulfate. Representative

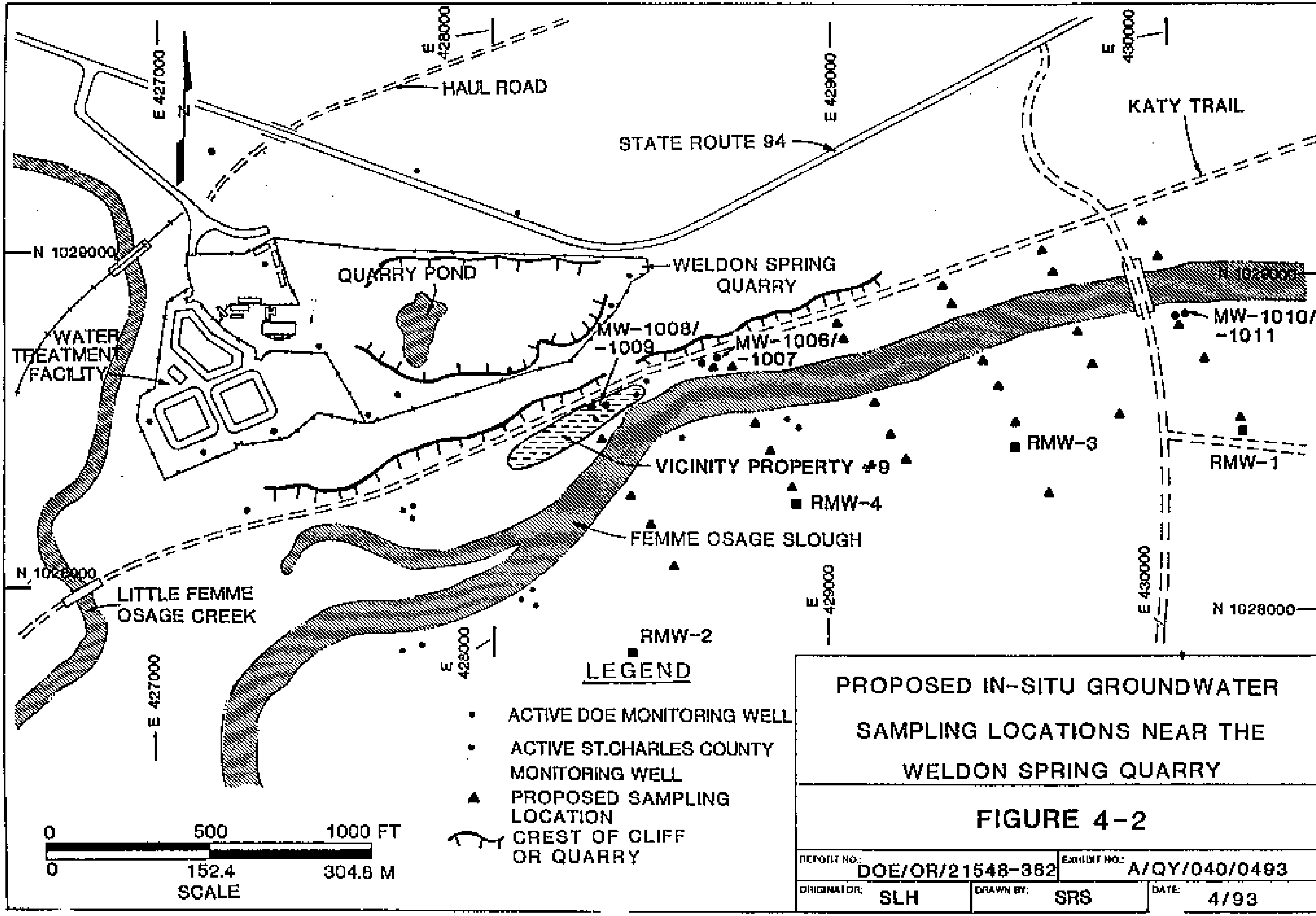


GEOPHYSICAL SURVEY LINES PROPOSED AS PART OF SUPPLEMENTARY ENVIRONMENTAL MONITORING INVESTIGATIONS

FIGURE 4-1

REPORT NO.: DOE/OR/21548-382	EXHIBIT NO.: A/QY/039/0493

ORIGINATOR: SLH	DRAWN BY: SRS	DATE: 4/93



PROPOSED IN-SITU GROUNDWATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 4-2

REPORT NO.: DOE/OR/21548-362		EXHIBIT NO.: A/QY/040/0493
ORIGINATOR: SLH	DRAWN BY: SRS	DATE: 4/93

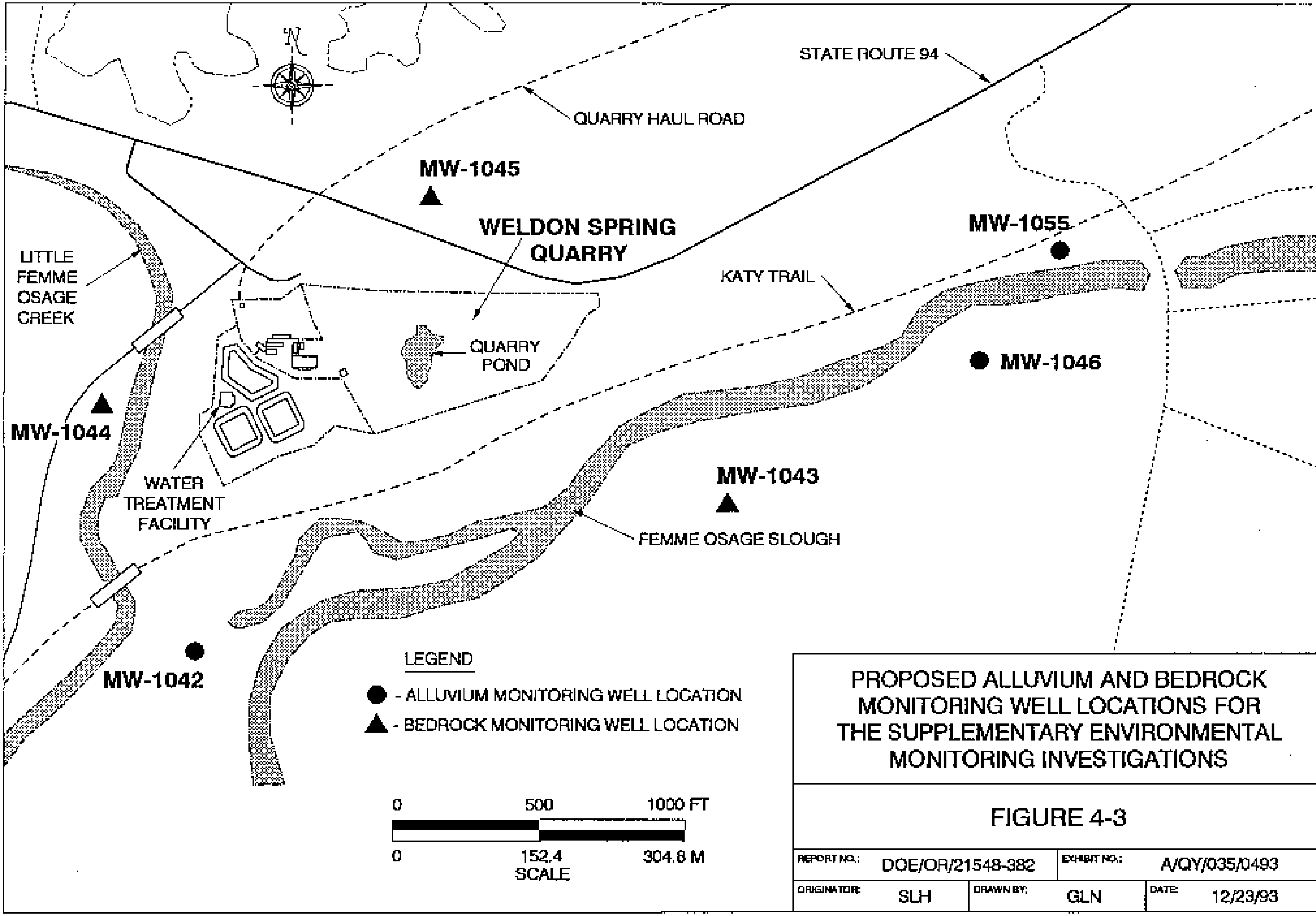
samples from each geological environment will be collected along lines perpendicular to the depositional trend of the alluvium using a groundwater sampler, such as BAT's Enviro Probe, through a hollow-stem auger. Holes will be plugged according to ES&H Procedure 4.4.4.

Pending results from the in situ sampling and geophysical surveys, three additional wells will be installed in the alluvium as shown in Figure 4-3. MW-1046 and MW-1042 are designed to obtain information on the easterly and westerly extent of the contaminant plume and the vertical gradient; MW-1055 is designed to determine the easterly component and the vertical gradient.

In addition to the alluvial wells, three wells will be drilled into the Plattin Formation as depicted in Figure 4-3. The purpose of well MW-1044 is to obtain background chemical data; MW-1043 and MW-1045 are designed to provide information on the extent of contamination. All three will be used to add data on the vertical gradient within the Plattin Formation.

4.3 Remedial Investigation/Feasibility Study Integration

The data from the routine environmental monitoring and the SMP will be reviewed to assess comparability with respect to the DQRs. Where appropriate, these efforts and the information which will be obtained from these programs will be used to support characterization efforts for the QROU and have been incorporated into this plan to minimize redundancy of effort; this plan addresses data requirements not covered by the above efforts.



PROPOSED ALLUVIUM AND BEDROCK MONITORING WELL LOCATIONS FOR THE SUPPLEMENTARY ENVIRONMENTAL MONITORING INVESTIGATIONS

FIGURE 4-3

REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/QY/035/0493	
ORIGINATOR: SLH	DRAWN BY: GLN	DATE: 12/23/93	

5 DATA REQUIREMENTS

5.1 Conceptual Model

This conceptual model was developed by Argonne National Laboratory (ANL) (1993) to detail sources, possible release and transport mechanisms, and potential receptors of contaminants at the Quarry Residuals Operable Unit (QROU) following bulk waste removal. The QROU includes material remaining at the quarry proper, the Femme Osage Slough, and other vicinity properties as detailed in Figure 5-1. Further information is contained in Section 3 of the Work Plan.

As described in Section 2 of this sampling plan, the original source of contamination was the bulk wastes placed in the quarry proper by the U.S. Department of Army (DA) and the U.S. Atomic Energy Commission (AEC) from the late 1940s through the late 1960s. The bulk wastes contained nitroaromatics, radionuclides, and other contaminants which have migrated to surrounding soils, surface water, sediments, and groundwater. Current sources of contamination are considered to be material located at the quarry proper, soils outside the quarry proper, and the water and sediment in the Femme Osage Slough.

There are two primary release mechanisms: (1) emissions of particulates and gases from the quarry proper and vicinity properties and (2) percolation/infiltration into the groundwater from these same areas and the Femme Osage Slough. Surface runoff from contaminated soils is considered a secondary release mechanism.

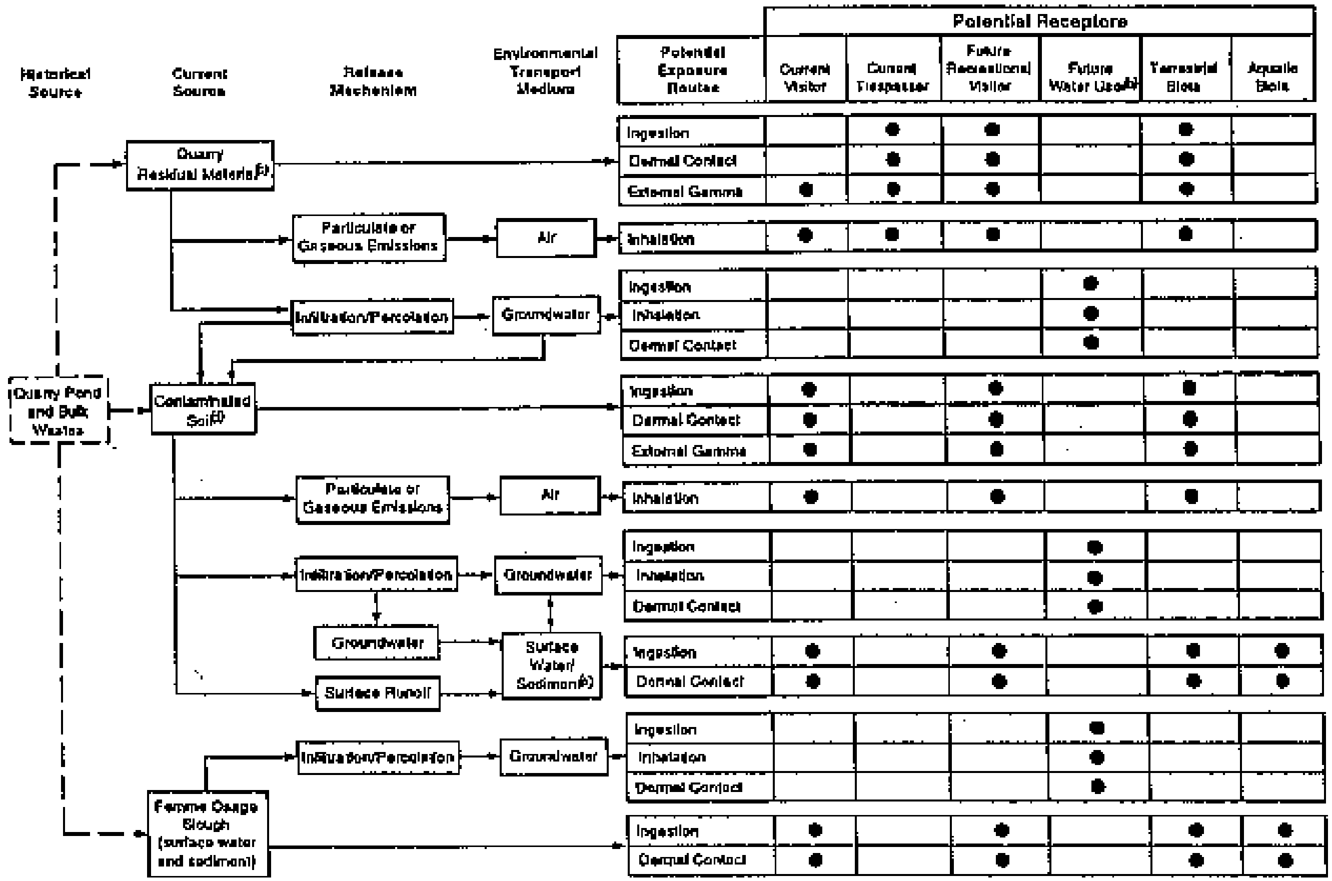
Potential receptors as envisioned by this model include a current or future visitor to the quarry proper or surrounding areas and the slough, a current trespasser at the quarry proper, and terrestrial or aquatic biota affected by one of the current sources.

5.2 Hydrogeological Data Requirements

Information required to support modeling and analysis of contaminant behavior for the Remedial Investigation/Feasibility Study (RI/FS) process should generally include:

- Geology, local stratigraphy, and structure
- Precipitation and evapotranspiration

Conceptual Site Model for the Quarry Residuals Operable Unit(a)



(a)Includes contaminated material located at the quarry proper, Femme Osage Slough, and other nearby areas.
(b)Included to assess the potential for migration of groundwater contaminants to the St. Charles County well field
(c)Includes contaminated soil, sediment, and sorbed contaminants on the quarry surface.
(d)Contaminated soil between Femme Osage Slough and the Katy Trail (vicinity property 9).
(e)Includes surface water and sediment at Femme Osage Slough and local creeks.

CONCEPTUAL SITE MODEL FOR THE QUARRY RESIDUALS OPERABLE UNIT

FIGURE 5-1

REPORT NO.: DOE/OR/21548-382	EXHIBIT NO.: A/PI/064/0493	
ORIGINATOR: SLH	DRAWN BY: SRS	DATE: 4/93

- Boundary conditions
- Groundwater flow characteristics
- Contaminant transport characteristics
- Seasonal influences on flow and transport
- Surface water/groundwater interaction
- Contaminant concentration distributions

Specific information requirements in terms of physical parameters are:

- Saturated Flow

  - Hydraulic conductivity (spatial distribution)
  - Thickness of individual formations
  - Storativity (specific yield)
  - Anisotropy (spatial distribution)

- Unsaturated Flow

  - Capillary moisture retention characteristics
  - Water content
  - Anisotropy (spatial distribution)

- Saturated transport

  - Effective porosity
  - Bulk density
  - Distribution coefficient (retardation factor)
  - Dispersion coefficient (longitudinal and transverse)
  - Fracture characteristics (spacing, aperture, direction, continuity, orientation)
  - Mineralogy

- Unsaturated transport

  - Effective porosity
  - Bulk density

- Mineralogy
- Retardation factors

The current level of understanding of the hydrogeology of the area is the result of previous studies performed to address water resources issues in the well field alluvium and waste storage in the quarry. As a result, the conceptual model incorporates a substantial amount of historical data related to site hydrogeology. Data used to develop the conceptual model are likely to be accurate because standard methods were used in the data collection and analysis. Previous investigations are described in Section 2.4 of this plan.

5.3 Contaminant Data Requirements

Investigations involving chemical and radiological characterization for the QROU have been performed. Routine monitoring of air, surface water, and groundwater is performed as part of the environmental monitoring program required under DOE 5400.1. Sediment and surface water sampling, as part of the Aquatic Biological Screening Investigation, is also ongoing (MKF and JEG 1992b). A detailed description of all previous data collected for the QROU can be found in the draft Work Plan (ANL 1993).

Data requirements have been identified, and information required to support characterization efforts for the RI/FS process generally include:

- Nature and magnitude of contamination
- Spatial and temporal extent of contamination
- Background sampling of surface water, groundwater, soil, and sediment
- Contaminant transport characteristics

5.3.1 Nature and Magnitude of Contamination

Previous investigations have identified contaminants in the area outside the quarry proper. However, additional information is required on contaminant types and concentrations. The following information will be needed to refine the potential contaminants of concern (PCOC) list.

- Identification and verification sampling for contaminant types and concentrations.

- Additional sampling for potential contaminants in order to determine mean concentrations and coefficients of variation.

5.3.2 Extent of Contamination

The spatial and temporal extent of contamination in the area outside the quarry proper has not been completely defined. Specific areas which need to be addressed are as follows:

- Spatial distribution of contaminants in surface water, sediment (Femme Osage Slough, Little Femme Osage, and Femme Osage Creeks), and soil (north and south of the Femme Osage Slough).

- Horizontal and vertical distribution of contaminants in groundwater. Information is still needed for the alluvium, Decorah Group, and Plattin Limestone. Additional data are needed for the groundwater within the Decorah Group and Plattin Limestone due east of the quarry proper, west and north of the quarry, and south of the slough.

- Spatial distribution of contaminants with depth in the Femme Osage Slough. Because seasonal stagnation has been observed in the slough, stagnant zones, which may be caused by density differences or differences in any mixing, must be evaluated.

- Information on the temporal distribution of contaminants in surface water and groundwater. Temporal sampling is needed to examine contaminant concentrations and their relationship to surface water stage and groundwater levels in the vicinity of the slough and creeks. If sufficient data are available, seasonal influences on contaminant concentrations can be assessed based on trend analysis of data.

5.3.3 Background Sampling

Previous background sampling is limited. In many cases, it is not site specific and is only for a limited number of parameters. Results from previous investigations involving the Weldon Spring Chemical Plant have often been referred to for background information. However, site-specific information relative to the QROU is necessary. Background information will be compared with site-specific data for contaminants.

Data requirements for background sampling include the following areas:

- Information on a slough environment for both surface water and sediment
- Alluvium soils
- Bedrock groundwater information for the Decorah Group and Plattin Limestone
- Additional groundwater information from the Darst Bottoms alluvial wells
- Sediment and surface water for the Little Femme Osage and Femme Osage Creeks
- Information from background sources on temporal variations in contaminant concentrations in surface water and groundwater

5.3.4 Contaminant Transport Characteristics

Information that must be gathered to examine the potential mobility/migration of contaminants in the QROU includes the following:

- The effect of filtered vs. unfiltered samples for groundwater and surface water
- Influence of size fraction, cation exchange capacity (CEC), and total organic carbon (TOC) on contaminant distribution in sediment and soil
- Correlation between contaminant concentrations in surface water with contaminant concentrations in nearby groundwater monitoring wells
- Correlation between contaminant concentrations in surface water with contaminant concentrations in underlying sediment
- The effect of potential redox reactions, ion speciation, system parameters (e.g., pH, Eh, DO, temperature), etc. on geochemical transport phenomena

5.4 Ecological Data Requirements

Ecological data requirements at the QROU exist in two broad areas: 1) the characteristics of aquatic and terrestrial biota in the QROU study area and 2) adverse toxicological effects on this biota as a result of the contamination in the quarry. Specific data requirements will include:

- An inventory of terrestrial vegetation in the study area
- An inventory of the herpetofauna in the study area
- A survey of endangered species in the study area
- A wetlands determination
- Determination of bioaccumulation in biota in the study area

6 DATA QUALITY OBJECTIVES

The data quality objective (DQO) process helps ensure that the right type and quality of information is collected and that the study design efficiently supports the decision-making process. DQOs have been established as part of the Work Plan and as a part of the remedial investigation process for the Quarry Residuals Operable Unit (QROU). Refer to the Work Plan for a complete explanation of the methodology used in determining the DQOs.

It should be noted that this sampling plan addresses only Phase I of the characterization efforts, and as information is developed from the data, the DQOs shall be reevaluated and a second, more quantitative, approach for this unit will be formulated. This will allow Phase IA to refine the potential contaminants of concern (PCOC) list (see Section 8.2.1 for PCOC) and establish baseline information from background sources for each media. Once this information is obtained, the DQOs will be reevaluated prior to Phase IB and issued as part of the report for Phase IA. Any changes or additions to the sampling plan as a result of the more quantitative approach to the DQOs will also be included in the report.

The parameters, analytical methods, and detection limits have been selected as shown in Table 6-1; however, it should be noted that for aquatic data purposes, detection limits may be lower. Table 6-2 provides precision and accuracy guidelines.

TABLE 6-1 Parameters and Target Detection Limits for Weldon Spring Quarry Residuals

	Analytical Method	WATER		SOIL	
		DL	Unit	DL	Unit
Radionuclides					
On-site[a]					
U-238, U-235, U-234	EPA 901.1	NA		1	pCi/g
Ra-226, Ra-228	EPA 901.1	NA		1	pCi/g
Off-site[b]					
Nat. uranium	EPA 908.0*	1	pCi/l	1	pCi/g
		1.5	μg/l	3	mg/kg[c]
Ra-226, Ra-228	EPA 903.1*	1	pCi/l	1	pCi/g
Th-230, Th-232	EERF 00/07*	1	pCi/l	1	pCi/g
Gross alpha	EPA 900.0*	3	pCi/l	3	pCi/g
Gross beta	EPA 900.0*	8	pCi/l	3	pCi/g

TABLE 6-1 Parameters and Target Detection Limits for Weldon Spring Quarry Residuals (Continued)

	Analytical Method	WATER		SOIL	
		DL	Unit	DL	Unit
Metals					
Aluminum	CLP	200	µg/l	20	mg/kg
Antimony[f]	CLP	60	µg/l	6	mg/kg
Arsenic	CLP	10	µg/l	1	mg/kg
Barium	CLP	200	µg/l	20	mg/kg
Beryllium	CLP	5	µg/l	0.5	mg/kg
Cadmium[f]	CLP	5	µg/l	0.5	mg/kg
Calcium	CLP	5000	µg/l	500	mg/kg
Chromium (III)	CLP	10	µg/l	1	mg/kg
Chromium (VI)		10	µg/l	1	mg/kg
Cobalt	CLP	50	µg/l	5	mg/kg
Copper[f]	CLP	25	µg/l	2.5	mg/kg
Iron	CLP	100	µg/l	10	mg/kg
Lead	CLP	3	µg/l	0.3	mg/kg
Lithium	EPA 200.7	50	µg/l	5	mg/kg
Magnesium	CLP	5000	µg/l	500	mg/kg
Manganese	CLP	15	µg/l	1.5	mg/kg
Mercury[f]	CLP	0.2	µg/l	0.1	mg/kg
Molybdenum	EPA 200.7	4	µg/l	0.4	mg/kg
Nickel	CLP	40	µg/l	4	mg/kg
Potassium	CLP	5000	µg/l	500	mg/kg
Selenium	CLP	5	µg/l	0.5	mg/kg
Silver[f]	CLP	10	µg/l	1	mg/kg
Sodium	CLP	5000	µg/l	500	mg/kg
Thallium	CLP	10	µg/l	1	mg/kg
Vanadium	CLP	50	µg/l	5	mg/kg
Zinc	CLP	20	µg/l	2	mg/kg
Inorganic Anions					
Chloride	EPA 300.0*	0.25	mg/l	50	mg/kg
Fluoride	EPA 300.0*	0.25	mg/l	50	mg/kg
Nitrate	EPA 300.0*	0.25	mg/l	50	mg/kg
Nitrite	EPA 300.0*	0.25	mg/l	50	mg/kg
Sulfate	EPA 300.0*	1.0	mg/l	200	mg/kg
Nitroaromatics					
1,3-DNB		0.09	µg/l	18	µg/kg[d]
2,4-DNT	HPLC	0.03	µg/l	6	µg/kg[d]
2,6-DNT	or	0.01	µg/l	2	µg/kg[d]
Nitrobenzene	GC	0.03	µg/l	6	µg/kg[d]
1,3,5-TNB		0.03	µg/l	6	µg/kg[d]
TNT		0.03	µg/l	6	µg/kg[d]
Volatiles					
Chloromethane	CLP	10	µg/l	10	µg/kg
Bromomethane	CLP	10	µg/l	10	µg/kg
Vinyl Chloride	CLP	10	µg/l	10	µg/kg
Chloroethane	CLP	10	µg/l	10	µg/kg
Methylene Chloride	CLP	10	µg/l	10	µg/kg
Acetone	CLP	10	µg/l	10	µg/kg

TABLE 6-1 Parameters and Target Detection Limits for Weldon Spring Quarry Residuals (Continued)

	Analytical Method	WATER DL	WATER Unit	SOIL DL	SOIL Unit
Carbon Disulfide	CLP	10	µg/l	10	µg/kg
1,1-Dichloroethene	CLP	10	µg/l	10	µg/kg
1,1-Dichloroethane	CLP	10	µg/l	10	µg/kg
1,2-Dichloroethene (total)	CLP	10	µg/l	10	µg/kg
Chloroform	CLP	10	µg/l	10	µg/kg
1,2-Dichloroethane	CLP	10	µg/l	10	µg/kg
2-Butanone	CLP	10	µg/l	10	µg/kg
1,1,1-Trichloroethane	CLP	10	µg/l	10	µg/kg
Carbon Tetrachloride	CLP	10	µg/l	10	µg/kg
Bromodichloromethane	CLP	10	µg/l	10	µg/kg
1,2-Dichloropropane	CLP	10	µg/l	10	µg/kg
cis-1,3-Dichloropropene	CLP	10	µg/l	10	µg/kg
Trichloroethene	CLP	10	µg/l	10	µg/kg
Dibromochloromethane	CLP	10	µg/l	10	µg/kg
1,1,2-Trichloroethane	CLP	10	µg/l	10	µg/kg
Benzene	CLP	10	µg/l	10	µg/kg
trans-1,3-Dichloropropene	CLP	10	µg/l	10	µg/kg
Bromoform	CLP	10	µg/l	10	µg/kg
4-Methyl-2-pentanone	CLP	10	µg/l	10	µg/kg
2-Hexanone	CLP	10	µg/l	10	µg/kg
Tetrachloroethene	CLP	10	µg/l	10	µg/kg
Toluene	CLP	10	µg/l	10	µg/kg
1,1,2,2-Tetrachloroethane	CLP	10	µg/l	10	µg/kg
Chlorobenzene	CLP	10	µg/l	10	µg/kg
Ethyl Benzene	CLP	10	µg/l	10	µg/kg
Styrene	CLP	10	µg/l	10	µg/kg
Xylenes (total)	CLP	10	µg/l	10	µg/kg
Semivolatiles					
Phenol	CLP	10	µg/l	330	µg/kg
bis(2-Chloroethyl)ether	CLP	10	µg/l	330	µg/kg
2-Chlorophenol	CLP	10	µg/l	330	µg/kg
1,3-Dichlorobenzene	CLP	10	µg/l	330	µg/kg
1,4-Dichlorobenzene	CLP	10	µg/l	330	µg/kg
1,2-Dichlorobenzene	CLP	10	µg/l	330	µg/kg
2-Methylphenol	CLP	10	µg/l	330	µg/kg
2,2'-oxybis(1-Chloropropane)[e]	CLP	10	µg/l	330	µg/kg
4-Methylphenol	CLP	10	µg/l	330	µg/kg
N-Nitroso-di-n-propylamine	CLP	10	µg/l	330	µg/kg
Hexachloroethane	CLP	10	µg/l	330	µg/kg
Nitrobenzene	CLP	10	µg/l	330	µg/kg
Isophorone	CLP	10	µg/l	330	µg/kg
2-Nitrophenol	CLP	10	µg/l	330	µg/kg
2,4-Dimethylphenol	CLP	10	µg/l	330	µg/kg
bis(2-Chloroethoxy)methane	CLP	10	µg/l	330	µg/kg
2,4-Dichlorophenol[f]	CLP	10	µg/l	330	µg/kg
1,2,4-Trichlorobenzene	CLP	10	µg/l	330	µg/kg
Naphthalene	CLP	10	µg/l	330	µg/kg

TABLE 6-1 Parameters and Target Detection Limits for Weldon Spring Quarry Residuals (Continued)

	Analytical Method	WATER DL	WATER Unit	SOIL DL	SOIL Unit
4-Chloroaniline	CLP	10	µg/l	330	µg/kg
Hexachlorobutadiene[f]	CLP	10	µg/l	330	µg/kg
4-Chloro-3-methylphenol	CLP	10	µg/l	330	µg/kg
2-Methylnaphthalene[f]	CLP	10	µg/l	330	µg/kg
Hexachlorocyclopentadiene[f]	CLP	10	µg/l	330	µg/kg
2,4,6-Trichlorophenol	CLP	10	µg/l	330	µg/kg
2,4,5-Trichlorophenol	CLP	50	µg/l	1700	µg/kg
2-Chloronaphthalene	CLP	10	µg/l	330	µg/kg
2-Nitroaniline	CLP	50	µg/l	1700	µg/kg
Dimethylphthalate	CLP	10	µg/l	330	µg/kg
Acenaphthylene[f]	CLP	10	µg/l	330	µg/kg
2,6-Dinitrotoluene	CLP	10	µg/l	330	µg/kg
3-Nitroaniline	CLP	50	µg/l	1700	µg/kg
Acenaphthene	CLP	10	µg/l	330	µg/kg
2,4-Dinitrophenol	CLP	50	µg/l	1700	µg/kg
4-Nitrophenol	CLP	50	µg/l	1700	µg/kg
Dibenzofuran	CLP	10	µg/l	330	µg/kg
2,4-Dinitrotoluene	CLP	10	µg/l	330	µg/kg
Diethylphthalate	CLP	10	µg/l	330	µg/kg
4-Chlorophenyl-phenyl ether	CLP	10	µg/l	330	µg/kg
Fluorene[f]	CLP	10	µg/l	330	µg/kg
4-Nitroaniline	CLP	50	µg/l	1700	µg/kg
4,6-Dinitro-2-methylphenol	CLP	50	µg/l	1700	µg/kg
N-nitrosodiphenylamine	CLP	10	µg/l	330	µg/kg
4-Bromophenyl-phenylether	CLP	10	µg/l	330	µg/kg
Hexachlorobenzene[f]	CLP	10	µg/l	330	µg/kg
Pentachlorophenol[f]	CLP	50	µg/l	1700	µg/kg
Phenanthrene[f]	CLP	10	µg/l	330	µg/kg
Anthracene[f]	CLP	10	µg/l	330	µg/kg
Carbazole	CLP	10	µg/l	330	µg/kg
Di-n-butylphthalate	CLP	10	µg/l	330	µg/kg
Fluoranthene[f]	CLP	10	µg/l	330	µg/kg
Pyrene[f]	CLP	10	µg/l	330	µg/kg
Butylbenzylphthalate	CLP	10	µg/l	330	µg/kg
3,3'-Dichlorobenzidine	CLP	10	µg/l	330	µg/kg
Benzo(a)anthracene[f]	CLP	10	µg/l	330	µg/kg
Chrysene	CLP	10	µg/l	330	µg/kg
bis(2-Ethylhexyl)phthalate	CLP	10	µg/l	330	µg/kg
Di-n-octylphthalate	CLP	10	µg/l	330	µg/kg
Benzo(b)fluoranthene[f]	CLP	10	µg/l	330	µg/kg
Benzo(k)fluoranthene	CLP	10	µg/l	330	µg/kg
Benzo(a)pyrene	CLP	10	µg/l	330	µg/kg
Indeno(1,2,3-cd)pyrene	CLP	10	µg/l	330	µg/kg
Dibenz(a,h)anthracene[f]	CLP	10	µg/l	330	µg/kg
Benzo(g,h,i)perylene	CLP	10	µg/l	330	µg/kg
Pesticides/PCBs					
alpha-BHC	CLP	0.05	µg/l	1.7	µg/kg

TABLE 6-1 Parameters and Target Detection Limits for Weldon Spring Quarry Residuals (Continued)

	Analytical Method	WATER		SOIL	
		DL	Unit	DL	Unit
beta-BHC	CLP	0.05	µg/l	1.7	µg/kg
delta-BHC	CLP	0.05	µg/l	1.7	µg/kg
gamma-BHC (Lindane)	CLP	0.05	µg/l	1.7	µg/kg
Heptachlor[f]	CLP	0.05	µg/l	1.7	µg/kg
Aldrin[f]	CLP	0.05	µg/l	1.7	µg/kg
Heptachlor epoxide[f]	CLP	0.05	µg/l	1.7	µg/kg
Endosulfan I[f]	CLP	0.05	µg/l	1.7	µg/kg
Dieldrin[f]	CLP	0.1	µg/l	3.3	µg/kg
4,4'-DDE[f]	CLP	0.1	µg/l	3.3	µg/kg
Endrin[f]	CLP	0.1	µg/l	3.3	µg/kg
Endosulfan II	CLP	0.1	µg/l	3.3	µg/kg
4,4'-DDD[f]	CLP	0.1	µg/l	3.3	µg/kg
Endosulfan sulfate	CLP	0.1	µg/l	3.3	µg/kg
4,4'-DDT[f]	CLP	0.1	µg/l	3.3	µg/kg
Methoxychlor	CLP	0.5	µg/l	17	µg/kg
Endrin ketone	CLP	0.1	µg/l	3.3	µg/kg
Endrin aldehyde	CLP	0.1	µg/l	3.3	µg/kg
alpha-Chlordane	CLP	0.05	µg/l	1.7	µg/kg
gamma-Chlordane	CLP	0.05	µg/l	1.7	µg/kg
Toxaphene[f]	CLP	5	µg/l	170	µg/kg
Aroclor-1016	CLP	1	µg/l	33	µg/kg
Aroclor-1221	CLP	1	µg/l	33	µg/kg
Aroclor-1232	CLP	2	µg/l	67	µg/kg
Aroclor-1242	CLP	1	µg/l	33	µg/kg
Aroclor-1248	CLP	1	µg/l	33	µg/kg
Aroclor-1254	CLP	1	µg/l	33	µg/kg
Aroclor-1260	CLP	1	µg/l	33	µg/kg

(a) In-house laboratory; for screening purposes only.
(b) Contracted laboratory.
(c) For soil, natural uranium assumed to be measured U-238 in the conversion of pCi/g to mg/kg (mg/kg x 0.68 = pCi/g).
(d) Soil detection limits are estimated and assumes that percent moisture is zero.
(e) Previously known as bis(2-Chloroisoprophyl) ether.
* Or equivalent method.
(f) Subject to lower dedection limit for aquatic data purposes.

TABLE 6-2 Data Quality Requirements for the WSSRAP Precision and Accuracy Guidelines for Characterization of the Quarry Residuals Operable Unit

Category	Analytical Parameter	Analytical Method[b]	MDC soil μg/g[b]	Precision[a] (soil)	Accuracy[a] (soil)	MDL[a] μg/l	Precision[a] (water)	Accuracy[a] (water)	Comments
Radiation Screening (for qualitative purposes only)	Gross Alpha	2.6.4 *	NA	NA	NA	NA	NA	NA	ES&H SOP
	Gross Beta/Gamma	2.6.3 *	NA	NA	NA	NA	NA	NA	ES&H SOP
Field Measurements	pH	4.5.1 *	NA	NA	NA	NA	20	NA	ES&H SOP
	Temperature	4.5.1 *	NA	NA	NA	NA	20	NA	ES&H SOP
	Conductivity	4.5.2 *	NA	NA	NA	NA	20	NA	ES&H SOP
	Specific Ions	4.5.5 *	NA	NA	NA	NA	20	NA	ES&H SOP
	Dissolved Oxygen	4.5.6a	NA	NA	NA	NA	20	NA	ES&H SOP
	Organic Vapors	3.1.1 *	NA	NA	NA	NA	20	NA	ES&H SOP
	Settleable Solids	4.5.7 *	NA	NA	NA	0.1	20	NA	ES&H SOP
Onsite Radiological Measurements (onsite laboratory analyses)	U-238, U-235	2.6.9*	1 pCi/g	50	50	NA	NA	NA	ES&H SOP
	Ra-226, Ra-228	2.6.9*	1 pCi/g	50	50	NA	NA	NA	ES&H SOP
	TH-230, Th-232	2.5.8*	2 pCi/g	50	50	NA	NA	NA	ES&H SOP
	Gross Alpha	2.4.3*, 2.4.7*	NA	NA	NA	3.3 pCi/l (air)	20 (air)	NA	ES&H SOP
	Uranium, total	2.6.5*	NA	NA	NA	0.68 pCi/l	30	30	ES&H SOP

TABLE 6-2 Data Quality Requirements for the WSSRAP Precision and Accuracy Guidelines for Characterization of the Quarry Residuals Operable Unit (Continued)

Category	Analytical Parameter	Analytical Method[b]	MDC soil $\mu g/g$[b]	Precision[a] (soil)	Accuracy[a] (soil)	MDL[b] $\mu g/l$	Precision[a] (water)	Accuracy[a] (water)	Comments
Off-site Radiological Measurements (off-site laboratory analyses)	Nat. Uranium	EPA 908.0	1 pCi/g	50	30	1 pCi/l	20	20	
	Ra-226, -228	EPA 903.1	1 pCi/g	50	30	1 pCi/l	20	20	
	Th-228, 230, 232	EERF 00/07	1 pCi/g	50	30	1 pCi/l	20	20	
	Gross Alpha	EPA 900.0	3 pCi/g	50	30	3 pCi/l	40	40	
	Gross Beta	EPA 900.0	3 pCi/g	50	30	8 pCi/l	40	40	
Nitroaromatic Compounds	TNT	HPLC or GC	0.006	50	50	0.03	20	20	
	2,4-DNT	HPLC or GC	0.006	50	50	0.03	20	20	
	2,6-DNT	HPLC or GC	0.002	50	50	0.01	20	20	
	1,3,5-TNB	HPLC or GC	0.006	50	50	0.03	20	20	
	1,3-DNB	HPLC or GC	0.018	50	50	0.09	20	20	
	Nitrobenzene	HPLC or GC	0.006	50	50	0.03	20	20	
Miscellaneous	TSS	EPA 160.2	NA	NA	NA	2	20	20	
	TDS	EPA 160.2	NA	NA	NA	4000	20	20	
	TOC	EPA 415.1				0.1	20	20	
	Lithium	EPA 200.7	5	50	50	50	20	20	
	MO	EPA 200.7	0.4	50	50	4	20	20	
	ZR	EPA 200.7	20	50	50	20	20	20	
	CR+3	EPA 200.7	-	50	50	10	20	20	

TABLE 6-2 Data Quality Requirements for the WSSRAP Precision and Accuracy Guidelines for Characterization of the Quarry Residuals Operable Unit (Continued)

Category	Analytical Parameter	Analytical Method[b]	MDC soil µg/g[b]	Precision[a] (soil)	Accuracy[a] (soil)	MDL[b] µg/l	Precision[a] (water)	Accuracy[a] (water)	Comments
Miscellaneous (cont.)	CR+6	Colorimetric	2	50	50	10	20	20	
	TOX	SW846 9020	5	50	50	5	20	20	
	NO3	300.0/353.1	50	50	50	250	20	20	
	SO4	300.0/375.1,.2	200	50	50	1000	20	20	
	CL	300.0/325.1,.3	50	50	50	250	20	20	
	FL	300.0/340.1,.2,.3	50	50	50	250	20	20	
	NO2	300/354.1,.2	50	50	50	250	20	20	
	% Moisture	ASTM	NA	50	NA	NA	NA	NA	
	pH (soil)	EPA 160.2	NA	50	NA	NA	NA	NA	
	Asbestos ACM/TEM	3.1.4	NA	NA	NA	NA	NA	NA	ES&H SOP
CLP-VOA	TCL	CLP	CRQL	As required by CLP		CRQL	As required by CLP		
CLP-Semivoa	TCL	CLP	CRQL	As required by CLP		CRQL	As required by CLP		
CLP-Pest/PCB	TCL	CLP	CRQL	As required by CLP		CRQL	As required by CLP		
CLP-Metals	AL	CLP-ICP	20	As required by CLP		200	As required by CLP		
	AS	CLP-AA	1	As required by CLP		10	As required by CLP		
	BE	CLP-ICP	0.5	As required by CLP		5	As required by CLP		
	CD	CLP-ICP	0.5	As required by CLP		5	As required by CLP		
	CR (Total)	CLP-ICP	1	As required by CLP		10	As required by CLP		

TABLE 6-2 Data Quality Requirements for the WSSRAP Precision and Accuracy Guidelines for Characterization of the Quarry Residuals Operable Unit (Continued)

Category	Analytical Parameter	Analytical Method[a]	MDC soil µg/g[b]	Precision[c] (soil)	Accuracy[c] (soil)	MDL[b] µg/l	Precision[c] (water)	Accuracy[c] (water)	Comments
CLP-Metals (cont.)	CU	CLP-ICP	2.5	As required by CLP		25	As required by CLP		
	PB	CLP-AA	0.3	As required by CLP		3	As required by CLP		
	HG	CLP-CV	0.1	As required by CLP		0.2	As required by CLP		
	NI	CLP-ICP	4	As required by CLP		40	As required by CLP		
	NA	CLP-ICP	500	As required by CLP		5000	As required by CLP		
	ZN	CLP-ICP	2	As required by CLP		20	As required by CLP		
	BA	CLP-ICP	20	As required by CLP		200	As required by CLP		
	AG	CLP-ICP	1	As required by CLP		10	As required by CLP		
	FE	CLP-ICP	10	As required by CLP		100	As required by CLP		
	K	CLP-ICP	500	As required by CLP		5000	As required by CLP		
	MN	CLP-ICP	1.5	As required by CLP		15	As required by CLP		
	MG	CLP-ICP	500	As required by CLP		5000	As required by CLP		
	SE	CLP-AA	0.5	As required by CLP		5	As required by CLP		
	V	CLP-ICP	5	As required by CLP		50	As required by CLP		
	TL	CLP-AA	1	As required by CLP		10	As required by CLP		
	SB	CLP-ICP	6	As required by CLP		60	As required by CLP		
	CA	CLP-ICP	500	As required by CLP		5000	As required by CLP		
	CO	CLP-ICP	5	As required by CLP		50	As required by CLP		

TABLE 6-2 Data Quality Requirements for the WSSRAP Precision and Accuracy Guidelines for Characterization of the Quarry Residuals Operable Unit (Continued)

Category	Analytical Parameter	Analytical Method[*]	MDC soil $\mu g/g$[b]	Precision[a] (soil)	Accuracy[a] (soil)	MDL[b] $\mu g/l$	Precision[a] (water)	Accuracy[a] (water)	Comments
CLP-Metals (cont.)									
Other parameters not listed		TBD	TBD	50	50	TBD	20	20	See Note

* See comment section
TBD To Be Determined
NA Not Applicable
MDC Minimum detected concentration
MDL Minimum detection limit
(a) Accuracy criteria reflect the maximum ± deviation from 100% recovery. Precision criteria reflect the maximum relative percent difference between duplicate values.
(b) Detection limits and/or methods may vary with each laboratory and assume a dilution factor of 1.0. The soil detection limits assume 100% solids content.
NOTE: Generic DQRs apply to media and/or analytical methods not listed in this table. Specific DQRs may be developed as a part of future sampling and analysis plans

7 HYDROGEOLOGIC INVESTIGATIONS SAMPLING PROGRAM

This section describes the activities which are proposed to satisfy the data requirements identified in Section 5.2 of this plan regarding geological, hydrological, and physical information, including justification, rationale, methods, and locations for tests and sample collection. These efforts focus on the physical characterization of the Missouri River alluvium, tributary alluvium, and bedrock formations of the Upper Ordovician System, as well as selected meteorological parameters.

Seven major activities, identified herein, constitute the Hydrogeological Investigations Program for the Quarry Residuals Operable Unit (QROU). These activities are:

- Drilling of 8 vertical boreholes and 3 angled boreholes.
- Fracture mapping.
- Collection of geological samples for physical and mineralogical characterization.
- Laboratory testing of geological samples for physical and mineralogical parameters.
- Aquifer testing.
- Hydrological surveys.
- Meteorological monitoring.

The activities detailed in this section will be coordinated to the extent necessary with the sampling activities described in Section 8, with supplementary environmental monitoring investigations being performed in compliance with DOE Order 5400.1 (MKF and JEG 1992c), as described in Section 4 and with hydrologic monitoring activities being performed in support of bulk waste removal and quarry pond dewatering. For example, proposed monitoring well locations have been selected to satisfy data requirements identified in Section 5, and drilling associated with well installation will be utilized to characterize the site hydrogeology. Drilling techniques and monitoring well construction are described in this section. Coordination and integration with relevant site environmental monitoring activities are discussed in Section 4.

7.1 Drilling

Eight vertical boreholes and three angled boreholes are proposed at locations depicted in Figure 7-1. The locations of the vertical holes correspond with contaminant data needs, and these holes will be completed as monitoring wells. Geological and hydrological information will be obtained during the drilling of these holes to determine lithologic characteristics, rock quality, permeability, and formation thicknesses. Table 7-1 summarizes information regarding each proposed borehole.

Two additional monitoring wells (MW-1047 and MW-1048) are proposed to be completed in the marginal alluvium north of the Femme Osage Slough. These wells are intended to provide additional information on contaminant distribution to the south and west of a known "hot spot" of groundwater contamination centered near existing well MW-1009.

One additional monitoring well (MW-1054) is proposed to be completed in the alluvium south of the Femme Osage Slough, approximately midway between existing wells MW-1019 and MW-1018. This location is intended to provide additional information on contaminant distribution south of the Femme Osage Slough.

Four additional monitoring wells are proposed for the Plattin Limestone. MW-1049 and MW-1050 are intended to provide information on potential vertical pathways in this geologic formation at locations immediately south of the quarry. MW-1051 is collocated with MW-1015 and MW-1016 (existing alluvial wells), and is primarily intended to assess vertical hydraulic and contaminant relationships downgradient of the waste source. Monitoring wells MW-1052 (Decorah Group) and MW-1053 (Plattin Limestone) are intended to provide information on background groundwater chemistry and lateral and vertical hydraulic gradients.

Angled holes will be drilled to assess the frequency and character of vertical discontinuities which may act as vertical pathways for contaminant migration within the bedrock. Angled holes will not be completed as monitoring wells. Angled holes will be drilled at a 60° angle from horizontal at orientations of N90°E, S20°W, and S30°E.

Appendix B lists existing and proposed monitoring wells according to Missouri State plane coordinates.

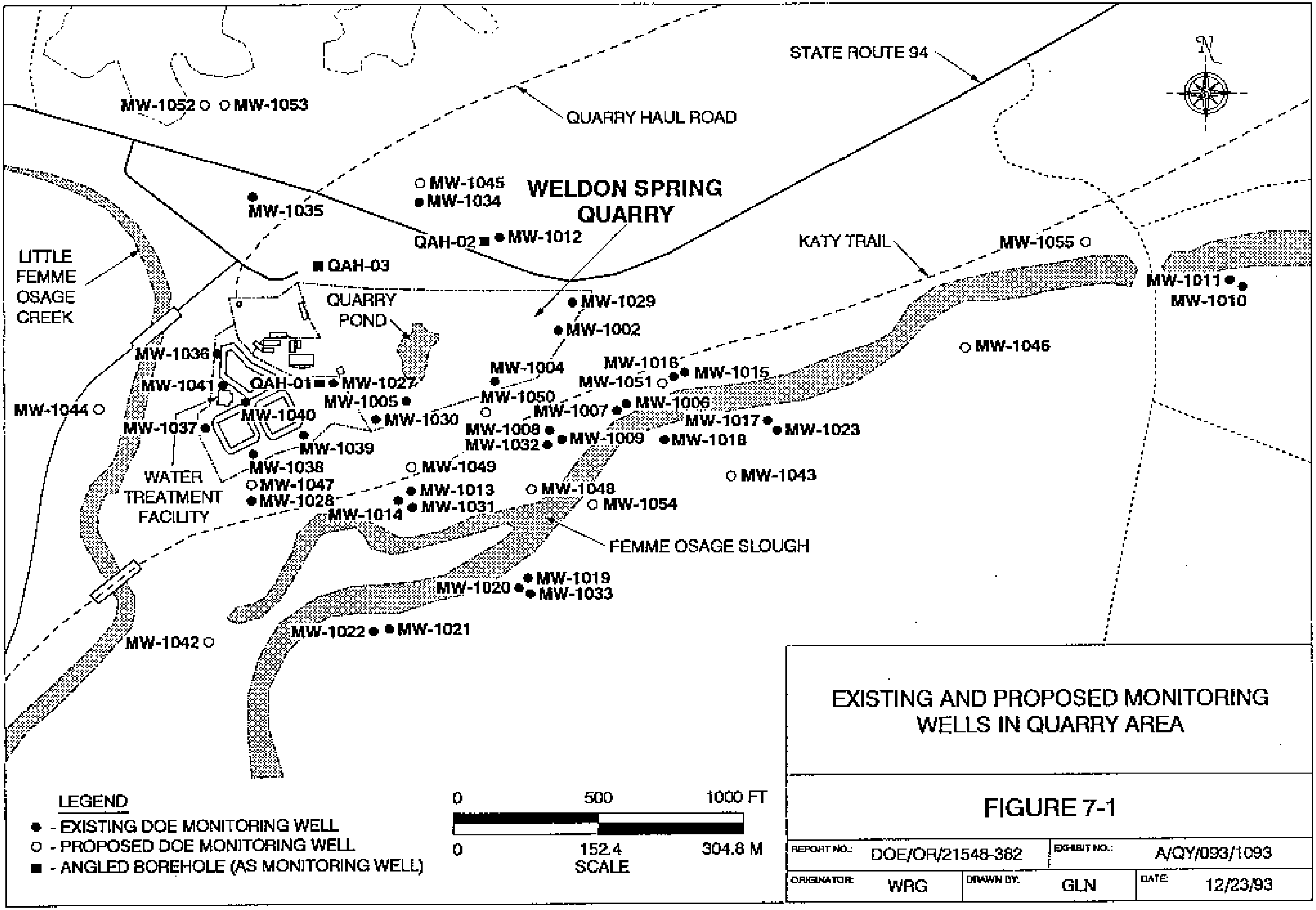

STATE ROUTE 94
QUARRY HAUL ROAD
WELDON SPRING QUARRY
KATY TRAIL
LITTLE FEMME OSAGE CREEK
QUARRY POND
WATER TREATMENT FACILITY
FEMME OSAGE SLOUGH
MW-1052
MW-1053
MW-1045
MW-1034
MW-1035
QAH-02
MW-1012
QAH-03
MW-1055
MW-1011
MW-1010
MW-1029
MW-1002
MW-1046
MW-1036
MW-1041
QAH-01
MW-1027
MW-1004
MW-1016
MW-1015
MW-1051
MW-1044
MW-1040
MW-1005
MW-1050
MW-1007
MW-1006
MW-1037
MW-1030
MW-1017
MW-1023
MW-1008
MW-1032
MW-1009
MW-1018
MW-1039
MW-1038
MW-1049
MW-1043
MW-1047
MW-1028
MW-1013
MW-1014
MW-1031
MW-1048
MW-1054
MW-1019
MW-1020
MW-1033
MW-1042
MW-1022
MW-1021
LEGEND
● - EXISTING DOE MONITORING WELL
○ - PROPOSED DOE MONITORING WELL
■ - ANGLED BOREHOLE (AS MONITORING WELL)
0
500
1000 FT
0
152.4
304.8 M
SCALE
EXISTING AND PROPOSED MONITORING WELLS IN QUARRY AREA
FIGURE 7-1
REPORT NO.: DOE/OR/21548-362
EXHIBIT NO.: A/QY/093/1093
ORIGINATOR: WRG
DRAWN BY: GLN
DATE: 12/23/93

TABLE 7-1 Summary of Information for Proposed Vertical and Angled Boreholes

Proposed Borehole	Location	Formation (Depth)	Rationale
MW-1047	With MW-1028	Alluvium (6-9 m)	Define vertical hydraulic gradient and southwesterly extent of contamination
MW-1048	60 meters SW of MW-1009	Alluvium (6-9 m)	Provide additional information regarding S-SW extent of contamination
MW-1049	Near MW-1030	Plattin Limestone (40-50 m)	Provide additional information on vertical extent of contamination and vertical gradients
MW-1050	35 meters south of MW-1004	Plattin Limestone (40-50 m)	
MW-1051	With MW-1015 and MW-1016	Plattin Limestone (40-50 m)	
MW-1052	North of quarry; off haul road	Decorah Group (15-20 m)	Provide background information for groundwater quality in shallow bedrock
MW-1053		Plattin Limestone (40-50 m)	
MW-1054	South of Femme Osage Slough	Alluvium (6-9 m)	Provide information on contaminant distribution south of Femme Osage Slough
QAH-01[a]	40 meters west of MW-1027 bearing N90°E	Decorah Group; Plattin Limestone; Joachim Dolomite (approx. 75 m)	Determine frequency and character of vertical discontinuities in Decorah Group, Plattin Limestone, and Joachim Dolomite
QAH-02[a]	With MW-1012 bearing S20°W		
QAH-03[a]	Near MW-1026 bearing S30°E		

[a] Angled boreholes — not to be completed as monitoring wells.

NOTE: All boreholes in bedrock to be pressure-tested during drilling to determine vertical trends in hydraulic conductivity.

Drilling methods were evaluated with respect to the types of geologic materials anticipated, previous site experience with drilling in this area, and the relative advantages and disadvantages of each method, as described by Aller et al. (1989). Drilling methods must be capable of advancing through both consolidated and unconsolidated materials above and below the water table. The proposed methods should utilize equipment which minimizes the potential for cross-contamination and surface and subsurface disturbance, while allowing for retrieval of representative geologic samples and performance of downhole tests. Based on these criteria, the following drilling methods are proposed:

- Hollow-stem augering (for unconsolidated materials)
- Water rotary (for rock coring)
- Air rotary (for rock reaming)

Samples will be continuously collected during drilling by means of pushing or driving sample tubes (in unconsolidated materials) and diamond coring techniques (in rock). Samples of sediment/soil will be collected for analyses of contaminants of interest as well as for physical and mineralogical testing.

The following general precautions will be taken to minimize the effects of drilling on the subsurface environment:

- All drilling equipment and tools will be decontaminated prior to initiation of drilling activities and between borings.

- All drilling operations will be performed with either air or potable water as a coolant/ lubricant. Other additives will not be used.

- Only Teflon tape or vegetable-based lubricants will be used on the threads of downhole drilling equipment. Oils, greases, or pipe dope shall not be used on pipe threads, drilling rods, downhole hammer bits, or other downhole tools. Similarly, no hydrocarbon-based oils or greases shall be used on rotary tables, slides, or other open, lubricated surfaces on the drilling rig.

Precautions will be taken at all times during drilling operations to prevent the contamination or cross-contamination of all wells and borings. Potential contaminants include, but are not limited to, oil, greases, hydraulic fluids, fuels, and contaminated soils.

All cuttings not sampled for laboratory analysis or other use, and all fluids generated as a result of drilling operations, will be managed in accordance with Weldon Spring Site Remedial Action Project (WSSRAP) Procedure RC-30, *Monitoring Well Waste Management*, which specifies either retention at the well location or on-site storage.

A qualified geologist, or geological engineer, will prepare a lithologic log for each borehole in accordance with the WSSRAP forms shown in Figures 7-2 and 7-3. Particular emphasis will be placed on recording lithology, stratigraphic features, and discontinuities which could affect contaminant transport to facilitate selection of screened intervals for the monitoring wells. The well-site geologist will also maintain observations of drilling rate, percent fluid circulation, sample recovery, and rock quality designation (RQD) as applicable.

During all drilling activities, a daily logbook will be maintained by the site geologist that will permit a re-creation of activities. The logbook will contain information not recorded on approved forms and may include sample recovery, grout density, monitoring of drilling operations, recording of water losses/gains, and groundwater elevation measurements. All well installation procedures will be recorded. The logbooks will be bound, printed on waterproof paper, and completed using waterproof ink or marker. Logbooks will contain, at a minimum, a legible listing of all personnel at the sampling location and their affiliation, a description of each sampling location, personnel visiting and/or inspecting and/or auditing the sampling crews, accidents, unusual occurrences or observations, weather conditions, and other relevant information necessary to allow a detailed re-creation of events. Logbooks will be signed daily by the recording person. All errors will be deleted by a single strike mark through the error, and the person correcting the error will initial and date the strike mark. Logbook maintenance is detailed in WSSRAP ES&H Procedure 1.1.4, *Logbook Procedure*.

Each drilling method and additional method-specific requirements and precautions are described in the following sections.

MK-ENVIRONMENTAL SERVICES

Project Number:	Boring Number: Sheet ____ of ____

SOIL BORING LOG

Project: ______________________ Location: ______________________

Elevation: ______________________ Drilling Contractor: ______________________

Drilling Method and Equipment: ______________________

Water Level and Date: ______________ Start ____________ Finish ____________ Logger: ____________

ELEVATION	DEPTH BELOW SURFACE	SAMPLE: INTERVAL	SAMPLE: TYPE & NUMBER	SAMPLE: RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION: Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol

BOREHOLE LOG FORM
FOR USE WITH
SOILS AND SEDIMENT

FIGURE 7-2

REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/PI/051/0393
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 3/93

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet ______ of ______

Project Number:

Hole Number

Project:	Location:
Coordinates:	Drilling Contractor:

Drill Make and Model:	Depth Top of Rock:	Depth Casing & Size:	Hole Size:

Elevation:	Angle from Vert. and Bearing:	Depth Bottom of Hole:

Water Level:	Fluid & Additives:	Date Start:	Date Finish:	Logger:

DEPTH	COMMENTS	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES			GRAPHIC LOG	LITHOLOGY
	TESTS/MONITORING INSTRUMENTATION CORING RATE AND SMOOTHNESS CORING FLUID LOSS CONTAMINATION				RQD	FRACTURES PER FOOT	DESCRIPTION TIGHTNESS PLANARITY SMOOTHNESS FILLING, STAINING ORIENTATION		MINERALOGY CLASSIFICATION COLOR GRAIN SIZE ALTERATION CEMENTATION HARDNESS WEATHERED STATE

BOREHOLE LOG FORM
FOR USE WITH ROCK

FIGURE 7-3

REPORT NO.: DOE/OR/21548-382	EXHIBIT NO.: A/PI/052/0393		
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 3/93	

7.1.1 Hollow-Stem Auger Drilling

Unconsolidated materials will be drilled using hollow-stem augering techniques. The diameter of augers will be determined by the specific purpose and requirements of each borehole. Minimum outside diameter will be 17.7 cm (7 in). Samples will be collected continuously during augering operations using split spoon samplers or other continuous sampling equipment. Samples will be collected before or during auger advance. A plug may or may not be used, depending upon the sampling method selected.

7.1.2 Rock Coring

In competent rocks, diamond coring drilling methods will be used. Portable recirculation tanks will be used to minimize the use of potable water. Water usage in terms of percent circulation and formation losses will be recorded during all water rotary drilling operations.

Rock coring will be accomplished using wireline methods in accordance with the American Society for Testing and Materials (ASTM) Standard Method D-2113. The core obtained will be standard NX diameter (approximately 5 cm [2 in]). A diamond-impregnated core bit and inner barrel will be used. The core will be collected by continuous coring from the top of the bedrock to the specified depth. The core will be collected to obtain information on lithological, mineralogical, and hydrological characteristics. Evidence of bedrock contamination will be noted, if encountered. Each core run will depend on drilling conditions but will not exceed 3 m (10 ft) in length. For angled holes, coring will proceed using a 1.5-m (5-ft) core barrel with a diamond-impregnated bit, yielding a nominal 5-cm- (2-in.-) diameter core.

The core will be placed in premanufactured wood core boxes designed to hold at least 3 m (10 ft) of core. The rock core will be clearly labelled to indicate proper vertical orientation, core intervals, core recovery, depth and location of samples, and RQD. Unconsolidated, very friable, or clayey sections of core will be placed in clear plastic sheeting, core tubing, or bags, and be sealed and stored along with the competent core in the core boxes. Cores will be logged and retained on site. Core losses will be noted by marked wooden blocks showing the approximate depth of the losses.

7.1.3 Air Rotary Drilling

Air rotary drilling will be used following coring operations and prior to well installation. This method is required to ream boreholes to a minimum diameter of 15 cm (6 in.) for single-cased wells and 30 cm (12 in.) for double-cased wells. The following precautions and requirements will apply to air rotary drilling operations:

- Specify the type of air compressor and compressor lubricating oil to be used. Retain a sample of each oil. Record oil consumption on the boring log. This information may be required for evaluation in the unlikely event that suspect constituents, possibly related to drilling activities, are detected in groundwater samples.

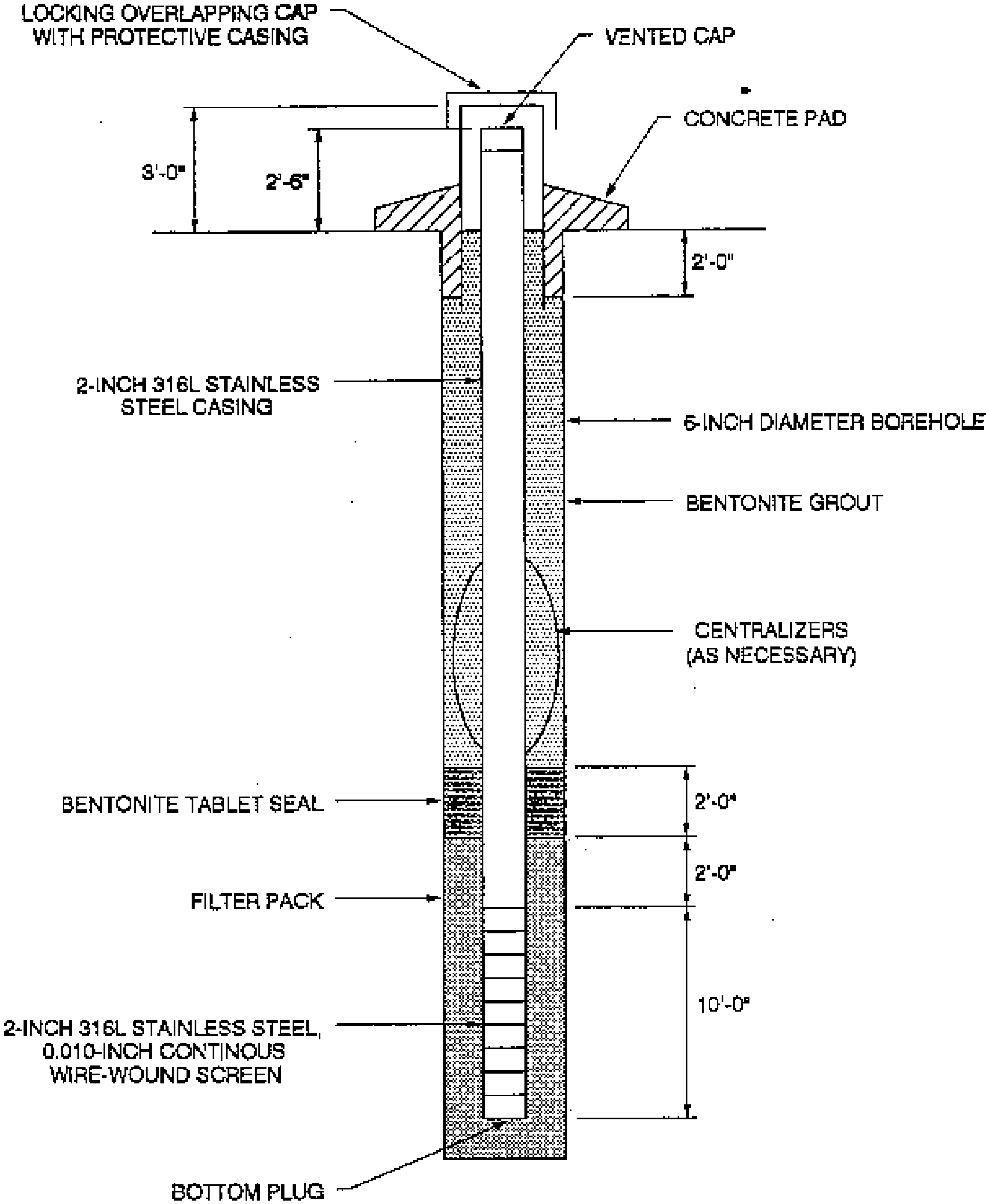
- Utilize an air-line oil filter maintained in accordance with the manufacturer's recommendations. This maintenance activity will be recorded on the boring log. Air filters will be changed with sufficient regularity to eliminate oil from filtered air.

- Fully describe air usage on the boring logs or in the daily logbook. Include equipment descriptions(s), manufacturer(s), model(s), air pressures used, frequency of oil-filter changes, and evaluations of the system performance.

7.1.4 Monitoring Well Construction and Development

Monitoring well installation will begin as soon as practicable at a maximum of 48 hours after drilling and coring activities are complete. The security and integrity of the borehole and subsequent well will be maintained by providing suitable barriers, tamper-detection seals, or locks to prevent unauthorized access. After beginning well installation, operation will not be stopped for extended breaks, the end of the regular work shift, or darkness until the bentonite seal has been emplaced above the filter pack. Figures 7-4 and 7-5 illustrate typical monitoring well design for single- and double-cased monitoring wells, respectively. Monitoring wells completed in the alluvium or upland bedrock will be constructed according to the following specifications and procedures:

- Prior to well installation, the borehole will be cleaned of cuttings.

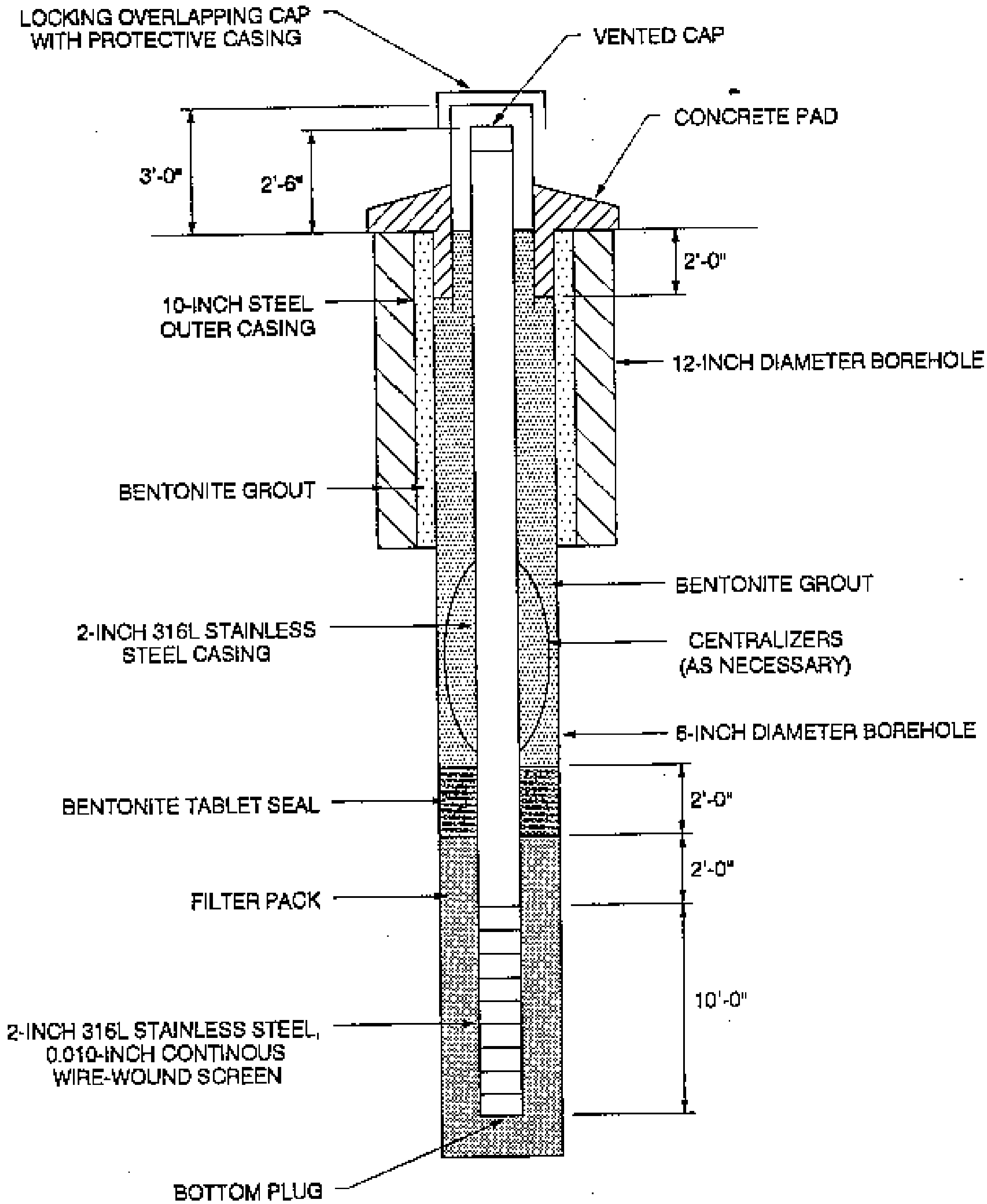


NOT TO SCALE

TYPICAL MONITORING WELL CONSTRUCTION
FOR SINGLE CASED WELLS

FIGURE 7-4

REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/PI/042/0393	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 3/93	



NOT TO SCALE

TYPICAL MONITORING WELL CONSTRUCTION FOR DOUBLE CASED WELLS

FIGURE 7-5

REPORT NO.:	DOE/OR/21548-382		EXHIBIT NO.:	A/PI/043/0393	
ORIGINATOR: JDC		DRAWN BY: GLN		DATE: 3/93	

- The well casing will be new, threaded, flush-jointed, Type 316L stainless steel with a nominal 5-cm (2-in.) inside diameter. All well casings will conform to the requirements of Type 316L stainless-steel casing or better.

- Continuous wire-wound, flush-jointed well screen will be used. The well screen will be constructed of 5-cm (2-in.) Type 316 stainless steel. Slot size shall be 0.25 mm (0.010 in.). Wells completed in alluvium will be constructed using 3-m (10-ft) screen lengths. Wells completed in bedrock will be constructed of 3-m (10-ft) screen lengths, or as open-hole wells.

- Well screen and well casing sections will be joined by threaded, flush-jointed couplings to form straight, water-tight unions. No solvents or glue will be used in the construction of the wells.

- The well screen will have a threaded stainless-steel bottom cap securely attached to provide a tight seal. The well casing shall have a threaded stainless-steel top cap. A vent hole, not to exceed 3 mm (1/8 in.) in diameter, shall be drilled in the side of the top.

- The following information shall be recorded (to the nearest 0.1 ft) both in the log book and on the well completion record: total depth drilled; total length of casing; location of well screen, filter pack (top and bottom), and bentonite seal interval. The datum for these measurements will be from ground surface and recorded as below ground surface.

- Each screen/casing assembly will be centered in the borehole using at least two stainless-steel centralizers at the bottom and top of the screen.

- The wells will be installed through either hollow-stem augers or temporary casing through the overburden or alluvium.

- The well assembly will be lowered upon 3 in. of filter pack material. Filter pack material will consist of clean, medium- to coarse-grained (70% retained by a 40-mesh sieve), well-rounded, uniform silica sand which shall be free of surface oxides. Filter pack will be added to the annulus to a height of 1 m (3 ft) above the screen. A weighted tape will be used to continuously tag the top of the filter pack to ensure accurate placement. The source of filter pack and gradational curves shall be provided.

- An annular seal will be constructed by placing 15-cm (6-in.) lifts of 6.3 mm to 9.5 mm (1/4-3/8 in.) bentonite tablets or prefabricated bentonite cylinders specifically designed for sealing purposes to a height of 1 m (3 ft) above the filter pack. Tablets will be hydrated by the addition of at least 5 liters (1.3 gal) of potable water per 15 cm (6 in.) lift if placed above the water table. Rock wells not suited to filter pack designs shall utilize a permanent packer to support the bentonite seal.

- The remaining annular space will be grouted to the surface using a side-discharge, tremie-placed, bentonite-based grout specifically designed for monitoring wells. The grout will be mixed according to the manufacturer's instructions regarding weights and measures by jetting through the hopper and will be circulated through the rig mud pump. This ratio will be properly documented. Grout mix must achieve a weight of 1.1 kg/l (9.4 lb/gal) prior to placement. Grout weight will be verified through the use of a mud balance.

- All depths and thicknesses including total depth of hole, filter pack thickness, and depth to top of bentonite seal will be checked and recorded using a weighted tape.

- Locking protective casings will be installed at each well. A concrete pad sloped to drain away from the well with minimum dimensions of 0.75 m (30 in.) by 0.75 m (30 in.) by 0.15 m (6 in.) will be installed. A brass monument will be set in the protective pad. At least three protective posts will also be installed to guard against incidental damage from vehicles.

- Following well installation, top of casing (TOC) elevations and the coordinates of each well will be surveyed by a licensed surveyor. TOC elevations will be to the nearest 0.003 m (0.01 ft). Horizontal control will be within 0.15 m (0.5 ft).

Monitoring wells completed in bedrock where the unconsolidated materials are saturated will be completed as described above; however, the following additional measures will be implemented to ensure the integrity of the completion:

- An outer casing will be installed at least 1.5 m (5 ft) into bedrock and grouted in place prior to coring and reaming to final depth.

- Coring and reaming will not commence until at least 48 hours after the outer casing has been grouted in place.

- Well completion will be as described previously. The annular space between the outer casing and the well casing will be filled with grout as previously described.

Wells installed during this investigation will be developed to produce clear water which is representative of natural groundwater. A variety of methods may be employed depending on the conditions encountered. Development activities will be specified or approved by the Project Management Contractor (PMC) and will be documented on the Well Development Form shown in Figure 7-6. The following guidelines will be used during well development activities:

- Development will not commence until at least 48 hours after the well casing has been grouted in place.

- Development methods will provide a surging action through the well screen and filter pack to remove soil and rock particles. Air lift devices will not be utilized for development purposes.

- Development will continue until surging fails to produce turbid water, three consecutive well volume samples yield conductivity, temperature measurements have stabilized within 20%, and pH measurements are stable within ± 0.5 standard units. Well volumes will be calculated based on the static water level in the well just prior to the onset of initial development. Well volume calculations will include saturated filterpack when appropriate.

Water generated during well development will be managed in accordance with WSSRAP Procedure RC-30, *Monitoring Well Waste Management*.

WELDON SPRING SITE REMEDIAL ACTION PROJECT
WELL DEVELOPMENT FORM

DATE ______________ PAGE _____ OF _____

WELL NUMBER _________ WELL SIZE WITH FILTER PACK $r = d/2 =$ _________ INCH

FIELD PERSONNEL ______________________________

TOTAL WELL DEPTH _______ ft - DEPTH TO SWL _____ ft = _______ ft WATER (L)

WELL VOLUME (CASING AND FILTER PACK) = (____^{2})(.163)(____ ft)= ____ (gl)

{VOLUME (WELL) = $r^2 \pi L$; FOR ANY WELL: V (gl) = [r^2 (in)] (.163) (L)}

L = LENGTH IN ft; r = RADIUS IN INCHES; .163 = CONVERSION FACTOR

DEVELOPMENT METHODS(S) ______________________________

BEGINNING TIME ______________________________

INITIAL WATER CONDITIONS ______________________________

	INITIAL	1	2	3	
TEMPERATURE	°C	°C	°C	°C	INSTRUMENTS USED
pH					
CONDUCTIVITY					
DISSOLVED OXYGEN					
WATER REMOVED	gl	gl	gl		gl

ESTIMATE RECHARGE RATE (gl) __________/__________

END TIME __________ FINAL SWL DEPTH __________

TOTAL WATER REMOVED ________ gl FINAL TURBIDITY MEASUREMENT ________ NTU

TOTAL WELL VOLUMES REMOVED (gl/WELL VOLUME) __________

FINAL WATER LEVEL __________ FINAL SWL DEPTH __________

COMMENTS ______________________________

PMC REPRESENTATIVE SIGNATURE ______________ DATE __________

WELL DEVELOPMENT FORM

FIGURE 7-6

REPORT NO.: DOE/OR/21548-382	EXHIBIT NO.: A/PI/045/0393	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 3/93

7.1.5 Equipment Decontamination

Equipment used in drilling operations and sample collection, and materials used in well construction, will be decontaminated according to the following guidelines:

- Drill rigs will be decontaminated with a hot-water, high-pressure washer prior to and upon completion of all drilling activities. Working areas of the drill rig will be decontaminated between boring locations. Pumps and hoses will be flushed with potable water between locations.

- Drilling equipment and tools will be decontaminated with a hot-water, high-pressure washer. They will be allowed to air-dry prior to and between borehole placement and upon arrival at the site. On wells with an outer casing, drilling equipment will be decontaminated before the outer casing has been installed and prior to coring or reaming activities. Equipment and tools will be stored in a manner that maintains the cleanliness of the equipment.

- Continuous samplers, split spoons, and other sampling equipment will be washed with potable water between samples in a given borehole if contaminant samples will not be collected. Continuous samplers and other sampling equipment will be cleaned in accordance with ES&H Procedure 4.1.3, *Sampling Equipment Decontamination*, and ES&H Procedure 4.4.5, *Soil/Sediment Sampling*, and allowed to air-dry prior to sample collection for contaminant analyses.

- All well screens, casings, caps, and outer casings will be cleaned using a hot-water, high-pressure washer and allowed to air-dry prior to installation. Cleaned materials will be stored in a manner that maintains their cleanliness.

- All well development tools and equipment will be cleaned using a hot-water, high-pressure washer and allowed to air-dry prior to initial use and between well drilling and installation activities. Cleaned materials will be stored in a manner that maintains their cleanliness.

Water and other wastes generated during decontamination activities will be collected and disposed of in accordance with WSSRAP Procedure RC-30.

7.1.6 Abandonment of Boreholes

Any well or borehole which is no longer required for sampling, testing, or monitoring will be plugged and abandoned in accordance with ES&H Procedure 4.4.4s, *Subsurface Monitoring Device Plugging and Abandonment Procedure*. This procedure has been developed to be consistent with plugging and abandonment practices as prescribed by 10 CSR 23-3.030(5) and 10 CSR 23-3.020(5). Briefly, the abandonment procedure generally consists of removing any existing pipe or casing, including screens, from the borehole. The borehole is then filled by tremie-placing a bentonite-based grout specifically designed for sealing boreholes. The ratio of clay grout to fresh potable water will be consistent with the manufacturer's instructions with respect to weights and measures. This ratio shall be verified in the field using a mud balance and be recorded by the PMC representative.

7.2 Fracture Mapping

Reproducible data regarding fractures in the bedrock are required to assess contaminant migration pathways. Past investigations have proposed that contaminant migration pathways exist in the lower Kimmswick Limestone, where vertical joints and bedding surfaces have been enlarged by dissolution, and in the rocks of the Decorah Group, which are thinly bedded and vertically fractured (BGA 1984). The fracture-mapping program proposed in this plan will utilize the rock exposures at the quarry, along the bluff to the south, to the north and west, and vertical and angled borehole data.

Surface measurements shall include fracture spacing, orientation, aperture, staining, etching, and continuity. Subsurface measurements shall include fracture spacing, orientation (to the extent possible), staining, etching, and aperture characteristics. Rock cores from previous investigations will be re-examined for fracture-related information. If necessary, existing cores will be relogged using the observational criteria established above for subsurface measurements. For example, some of the existing cores were not originally evaluated for RQD and must be re-examined to obtain those data to the extent possible.

Field notations, measurements, and core descriptions shall be recorded in field notebooks or on log forms. Measurements and stations will be tabulated and located on an appropriately scaled map. Measurements shall be plotted using rose diagrams and shall be statistically evaluated. The PMC shall direct the production of a data report presenting the results of fracture-mapping efforts and analysis. Further analysis of fracture data may be performed to support the analytical or numerical modeling performed to assess contaminant transport characteristics.

7.3 Sample Collection

Samples of representative geological materials will be collected during drilling activities and submitted for laboratory testing to determine representative physical and mineralogical properties. Sample collection methods will be consistent with methods described by Aller et al. (1989) and ASTM for soil sampling and rock coring. Specific ASTM methods are referenced in the following subsections where appropriate.

7.3.1 Unconsolidated Materials

Sampling techniques for unconsolidated materials will utilize both disturbed and undisturbed sample collection techniques. Disturbed samples will be collected using a split barrel sampler that is of standard dimensions and is driven by an 18-kg (140-lb) weight dropped through a 76-cm (30-in.) interval in general accordance with ASTM Standard Method D 1586. The number of blows required to drive the sampler will be recorded by the PMC representative. Alternatively, equipment which utilizes a continuous tube sampling method such as that offered by Central Mine Equipment, Inc., (CME) or equivalent may be employed. These methods will be used to collect samples for chemical and radiological analysis, as well as samples for grain size distribution, mineralogy, bulk density and organic content. Samples will be described for typical geological and engineering properties using standard practices as prescribed by ASTM D 2488. Samples will be classified using the Unified Soil Classification System (USCS), and color will be determined using the Munsell Soil Color Charts. Where applicable, additional notations will be made regarding the degree of sorting, dominant grain size, degree of saturation, and reaction to dilute hydrochloric acid.

Undisturbed samples will be collected using thin-walled tubes in accordance with ASTM Standard Method D 1587 by pushing a tube into the formation of interest in a relatively rapid and continuous motion. Care will be taken to avoid rotating the drill stem during thin-walled tube sampling. Thin-walled tubes shall be sealed at both ends with beeswax, plastic caps, and duct tape to preserve existing moisture conditions. Undisturbed samples will be obtained for saturated hydraulic conductivity testing, capillary moisture retention characteristics, moisture content, porosity, and cation exchange capacity (CEC).

Table 7-2 summarizes the number of samples to be collected for each type of analysis based on the present knowledge of geological characteristics of the study area.

TABLE 7-2 Summary of Physical and Mineralogical Laboratory Testing Program

Parameter (Method)	Alluvium North of Femme Osage Slough	Alluvium South of Femme Osage Slough	Sample Type	
			Disturbed	Undisturbed
Capillary soil moisture retention characteristics	10	5		X
Grain size	10	10	X	X
Volumetric moisture content	10	5		X
Bulk density	10	5	X	X
pH	10	5	X	X
CEC	10	5	X	X
TOC	10	5	X	X
Mineralogy	5	5	X	X
Saturate hydraulic conductivity	10	5		X

7.3.2 Rock Core

Rock core samples will be obtained using continuous coring techniques as discussed in Section 7.1. Rock cores will be handled in general accordance with ASTM Standard Practice D 2113 regarding storage and transportation. Additionally, total core length, percent recovery, rock quality designation, fluid loss or gain, coring rate, rock classification and lithologic characteristics, and discontinuities.

7.3.3 Sample Shipment and Chain of Custody

Chain of custody and sample shipping will follow WSSRAP SOPs ES&H 4.1.2, RC-17, and RC-19 as applicable. All samples shall be considered potentially contaminated and treated accordingly. Samples will be surveyed at the quarry access control point for radioactive contamination prior to off-site release.

7.4 Laboratory Testing

Physical and mineralogical testing is required to provide valid and sufficient data for each soil and geological strata subject to investigation under this plan. Previous investigations have not generated appreciable information in this regard. The information generated from the proposed testing program will be used to assess contaminant behavior in terms of mobility and fate by evaluating the transport characteristics and attenuation potential of geologic samples. Table 7-2 summarizes the testing program in terms of strata of interest, number of tests, and sample types.

Unconsolidated materials from the vadose zone will be tested for capillary moisture retention characteristics, grain size distribution, volumetric moisture content, bulk density, pH, CEC, TOC content, and mineralogy. Unconsolidated materials from below the water table will be tested for saturated hydraulic conductivity, grain size distribution, bulk density, moisture content, pH, CEC, TOC content, and mineralogy.

Laboratory tests of rock core samples are not presently scheduled, since properties governing flow in fractured rocks are usually not well suited to characterization by laboratory methods. If information obtained during the remedial investigation suggests that particular tests of rock samples would be beneficial to the understanding of contaminant fate or mobility, then a testing program will be devised to satisfy those data needs using the rock cores obtained as part of this plan.

7.5 Aquifer Testing

Quantifying the physical parameters associated with groundwater movement and contaminant transport is necessary to provide reliable and reproducible information for use in analytical or numerical analysis of groundwater flow and contaminant transport. The parameters which govern groundwater flow and contaminant transport are identified in Section 5 of this plan. A combination of the tests and measurements proposed in this plan and information generated from previous investigations will be used to assess influences on groundwater flow and contaminant transport. These parameters will be obtained by performing specific tests and physical measurements on the various hydrogeologic units within the QROU study area.

Previous investigations of the quarry and well field area have focused on determining aquifer characteristics for the saturated bedrock and alluvium. Pumping and pressure tests were performed in the quarry by the U.S. Geological Survey (USGS) (Richardson 1960). A pumping test of the quarry pond indicated that the pond is hydraulically connected to the shallow carbonate aquifer, and that the potential exists for migration of contaminants from the quarry to the Missouri River floodplain due to the eastward hydraulic gradient. Pressure testing performed in the lower 3 m (10 ft) of the Kimmswick Limestone and the upper 10 m (30 ft) of the Decorah Group indicated that the permeability within the shallow bedrock decreases with depth (Richardson 1960). Additional hydrologic monitoring associated with quarry pond dewatering activities are proposed in Section 7.6 of this plan.

Lawrence Berkeley Laboratory (LBL) conducted several pumping and tracer tests to determine the hydraulic properties of the shallow bedrock in the vicinity of the quarry and alluvium south of the Femme Osage Slough (BGA 1984). Pumping tests performed in the alluvium south of the slough consisted of two transient tests and two steady-state tests. Tracer tests performed in the alluvium south of the slough consisted of two converging flow tracer tests of 40 hr in duration, and four point dilution tracer tests which ranged up to about 4.5 hr in duration. Efforts by LBL to perform pumping tests of the alluvium north of the slough were abandoned due to low permeability conditions which required low pumping rates and extended recovery times. LBL performed 10 pumping tests in the fractured carbonate bedrock at locations between the quarry and the Femme Osage Slough. These tests ranged up to approximately 65 hr in duration. Tracer tests performed in the fractured carbonate bedrock consisted of one multi-well convergent configuration test of approximately 5 hr in duration, and one point dilution test of approximately 4 hr in duration. The results of these tests are provided in Section 3.2 of this plan, and additional discussion of these efforts is contained in the Work Plan (ANL 1993). The aquifer characterization efforts undertaken by LBL and the subsequent documentation of these efforts by BGA (1984) provide considerable insight regarding hydraulic properties (transmissivity, storativity, groundwater flow velocity, and effective porosity) of the shallow bedrock formations south of the quarry, and the alluvium south of the Femme Osage Slough.

Aquifer properties for that portion of the alluvial aquifer being utilized by St. Charles County as a source of drinking water were determined by Layne-Western Company (LWC), who performed a large-scale pumping test of PW-8 in order to more fully define the hydrologic flow characteristics of the alluvial aquifer and to aid in the design of a steady-state, passive-element, electric analog model. This test involved a pumping rate of 9.5E-02 m^3/s (1,500 gpm) for a period of 83 hr. The resulting analyses indicated a transmissivity of between 5.42E-02 m^2/s and 6.47E-02 m^2/s (377,000 and 450,000 gpd/ft) (LWC 1986).

In summary, the information generated by previous investigations has provided a substantial amount of useful data that may be used to assess the hydrologic controls that affect groundwater flow and contaminant transport in the vicinity of the quarry and adjacent well field. The focus of previous work has also been used to plan proposed investigations in a manner that minimizes redundancy. The dependence on previous work is especially acute with regard to proposed activities regarding aquifer testing. With the extent and focus of previous investigations in mind, additional pumping tests are not proposed at this time as a means of obtaining additional information regarding aquifer properties. Additional tests in the form of slug tests and packer (pressure) tests are proposed to determine horizontal and vertical variations in hydraulic conductivity for the saturated geologic media in the study area. Long-term tracer tests are also proposed to confirm transport characteristics for the alluvium in the vicinity of the Femme Osage Slough.

Tracer tests are described generally in this plan, and detailed performance and analysis requirements will be developed at a later date. These will provide the operational detail for the execution of the tests. Packer tests will be performed during borehole drilling and are included within the scope of the existing drilling services subcontract.

Treatability testing as proposed in the Work Plan may require further testing of the saturated alluvium north of the Femme Osage Slough. The testing required to determine the hydrogeological parameters necessary to support a groundwater treatability assessment will be determined once the scoping process for treatability testing has been completed.

7.5.1 Slug Tests

Also known as single-well hydraulic conductivity tests, slug tests determine the hydraulic conductivity of the saturated zone around a well screen or intake. Slug tests are advantageous because they obtain in situ data, can be used to determine aquifer heterogeneity, are relatively simple to conduct, and do not require separate pumping and observation wells. A disadvantage is that they only test the material near the well.

Slug tests will be performed on all existing monitoring wells and all proposed wells not subjected to packer tests to provide information on the variability of hydraulic conductivity. The results will be compared to pumping test results from previous investigations and packer test results.

Slug tests will be performed in accordance with WSSRAP Procedure ES&H 4.3.2, *Single Well Hydraulic Conductivity Testing*. Both rising and falling head tests will be performed. The procedure for performing slug tests generally consists of establishing the pre-test water level using a pressure transducer, introducing (or removing) a slug of known volume, and recording water levels as the well returns to steady-state conditions. The length of time required to perform each slug test will vary depending on the hydraulic conductivity. Standard pressure transducers and data loggers will be utilized to obtain water level measurements as recommended in ASTM D 4050.

Principle analytical methods will utilize procedures recommended in ASTM D 4104 and may include Bouwer and Rice (1976) or Hvorslev (1951) for unconfined conditions and Cooper et al. (1967) for confined cases.

7.5.2 Packer Tests

Packer, or pressure, tests are used to provide hydraulic conductivity information for competent rocks. They are performed by isolating a drill hole interval with inflatable packers and injecting water under pressure into the adjacent formation. The relationship between pressure and injection rate permits a calculation of hydraulic conductivity.

Packer tests will be performed on all borings advanced into bedrock. Bedrock units will be tested every 3 m (10 ft) with additional tests possibly performed at fracture zones identified during coring operations. These data will provide information on the horizontal and vertical variability of hydraulic conductivity for bedrock aquifer units.

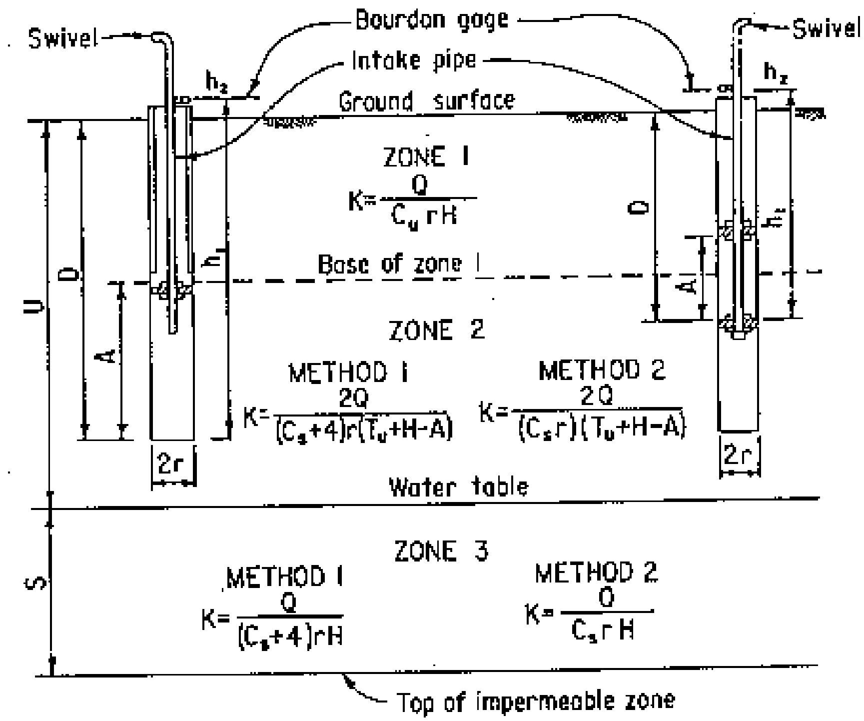
Packer testing will be performed during coring operations. Each 3-m (10-ft) interval will be tested during coring using standard packer testing equipment. Tests will be conducted using a single inflatable packer with water flow and pressure monitored with a flow meter and pressure gauge, respectively. Generally, three tests of 5 min duration will be performed at each test interval. Once the test section has been cored, the hole will be briefly flushed with potable water and the core barrel will be removed. The drill assembly will then be pulled to a point just above the test interval. The packer assembly and associated piping will be lowered and set at the interval to be tested. The packer will be inflated with inert gas. After the packer is securely seated, the hole will be pressurized to the desired pressure and allowed to stabilize, and the flow rate will be monitored. The initial test will be conducted at an approximate pressure of 10 psi to 60 psi. Another test will be conducted at approximately 20 psi to 90 psi, and a final test will be run at 10 psi to 60 psi. For each test, the inflow pressure, average flow, length of test interval, and total head will be recorded on test logs.

Packer testing data will be analyzed using methods described in the Groundwater Manual (U.S. Department of the Interior 1977, Zeigler 1976). Figure 7-7 presents applicable schematic details and equations and defines variables to be used in packer test data analysis.

7.5.3 Tracer Tests

Natural gradient tracer tests will be performed at two locations as shown in Figure 7-8 to determine transport characteristics within the Femme Osage alluvium. Natural gradient tracer tests involves monitoring a small volume of tracer as it moves through the natural flow system. Concentration measurements made at different times are used to determine advective velocities and dispersion (Domenico and Schwarz 1990). Natural gradient tracer tests rather than convergent flow tracer tests are proposed because of the logistical considerations associated with pumping significantly large volumes of contaminated water. The proposed locations were selected for the following reasons:

- The granular nature of the alluvium is well suited to an assessment of transport processes using tracers due to the porous media principles which govern analysis of advective flow.



SOURCE: U.S DEPARTMENT OF INTERIOR (1977)

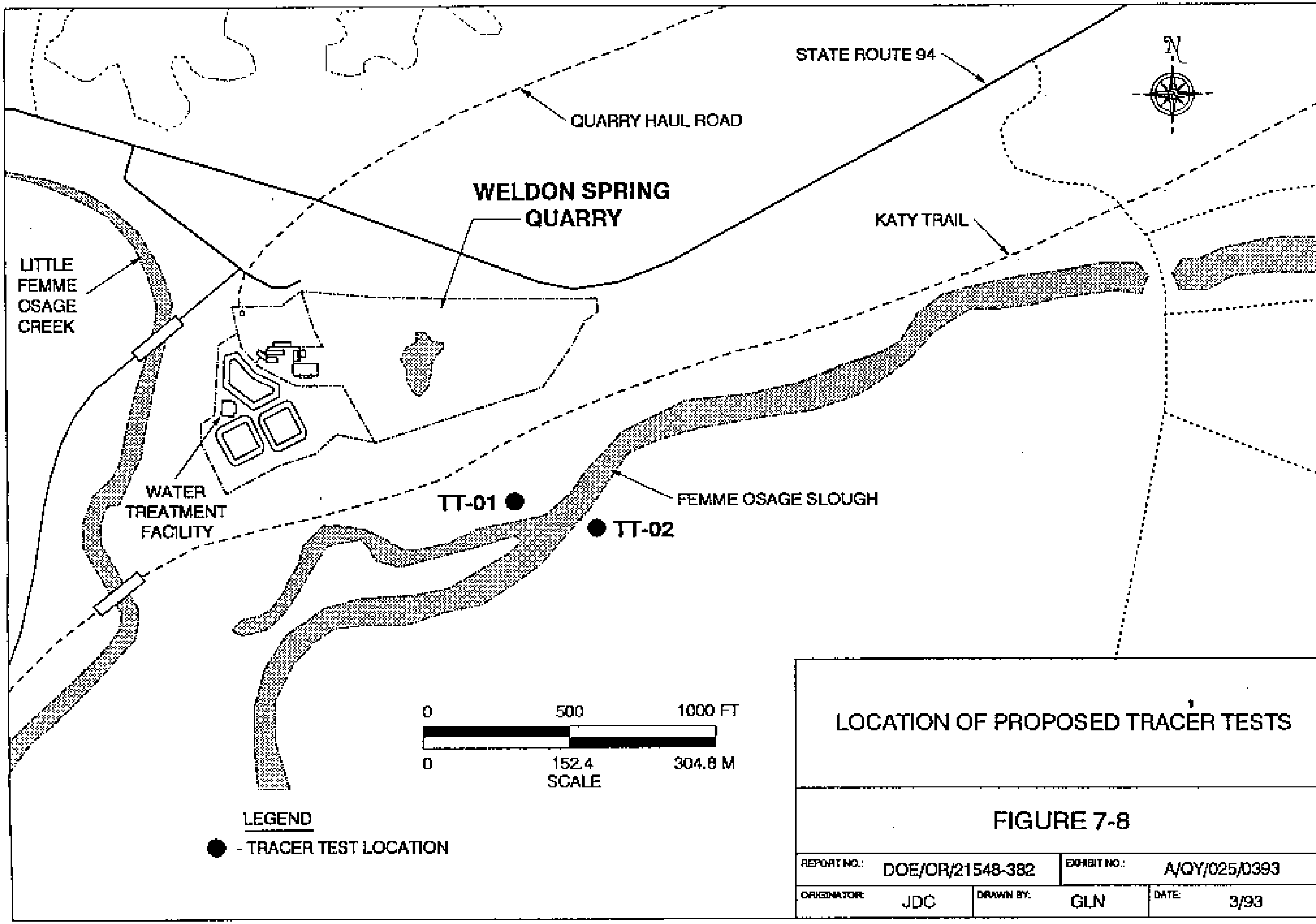
K = coefficient of permeability, feet per second under a unit gradient
Q = steady flow into well, ft^3/s
$H = h_1 + h_2 - L$ = effective head, ft
h_1 (above water table) = distance between Bourdon gage and bottom of hole for method 1 or distance between gage and upper surface of lower packer for method 2, ft
h_1 (below water table) = distance between gage and water table, ft
h_2 = applied pressure at gage, 1 lb/in^2 = 2.307 ft of water
L = head loss in pipe due to friction, ft; ignore head loss for Q<4 gal/min in $1\frac{1}{4}$ - inch pipe; use length of pipe between gage and top of test section for computations
$X = \frac{H}{T_u}(100)$ = percent of unsaturated stratum
A = length of test section, ft
r = radius of test hole, ft
C_u = conductivity coefficient for unsaturated materials with partially penetrating cylindrical test wells
C_s = conductivity coefficient for semi-spherical flow in saturated materials through partially penetrating cylindrical test wells
U = thickness of unsaturated material, ft
S = thickness of saturated material, ft
$T_u = U - D + H$ = distance from water surface in well to water table, ft
D = distance from ground surface to bottom of test section, ft
a = surface area of test section, ft^2; area of wall plus area of bottom for method 1; area of wall for method 2

Limitations:
$Q/a \leq 0.10$, $S \geq 5A$, $A \geq 10r$, thickness of each packer must be $\geq 10r$ in method 2

PERMEABILITY TEST SET, UP FOR SATURATED AND UNSATURATED BEDROCK

FIGURE 7-7

REPORT NO.: DOE/OR/21348-382		EXHIBIT NO.: A/PI/050/0392	
ORIGINATOR: LMK	DRAWN BY: SRS	DATE: 3/92	



LOCATION OF PROPOSED TRACER TESTS

FIGURE 7-8

REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/QY/025/0393	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 3/93	

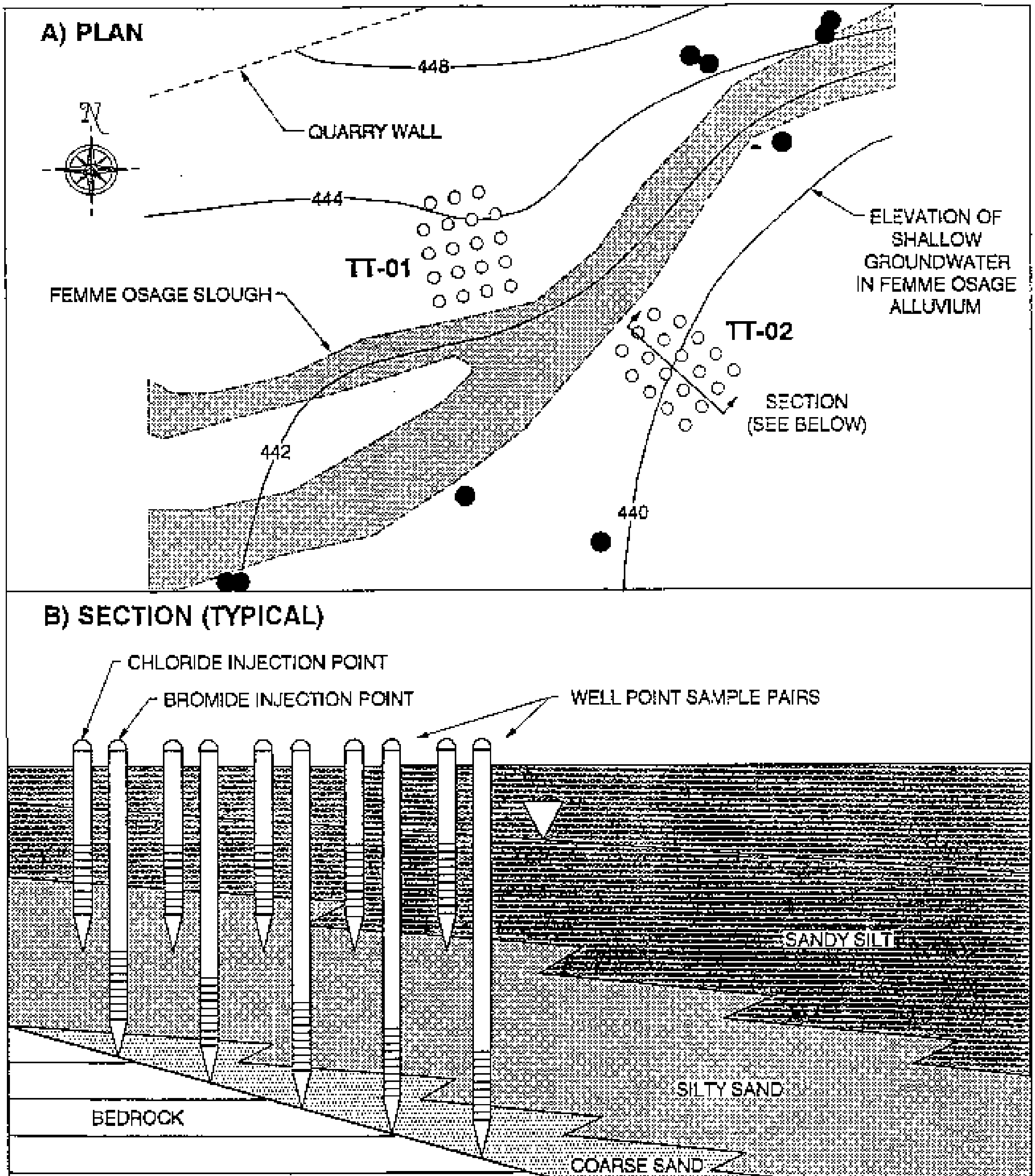
- The current understanding of groundwater flow and contaminant distribution suggests that geologic and hydrologic controls on flow and transport processes in the vicinity of the Femme Osage Slough are variable.

- Substantial uncertainty exists concerning the potential for future impacts to the St. Charles County well field from contaminated groundwater located north of the Femme Osage Slough.

The technique typically requires a dense network of sample points. For this reason, sandpoints (or well points) will be used to establish a grid at each location. Sandpoints are prefabricated, small-diameter well assemblies consisting of a welded continuous-slot screen attached to a forged-steel point. The most common sizes are designed for direct attachment of either 32-mm (1.25-in.) or 51-mm (2-in.) pipe (Driscoll 1986). Screen length is typically about 91 cm (36 in.). These units can be easily driven into unconsolidated sandy or silty formations.

Salts of chloride or bromide are proposed as the tracers for these tests. Chloride and bromide are favorable tracers because they are relatively benign compounds with respect to environmental concerns and are generally non-reactive. Site environmental monitoring data for 1990 indicate that chloride concentrations in groundwater for wells located near the proposed test location north of the Femme Osage Slough ranged from 20.5 mg/l to 79.8 mg/l. Chloride concentrations in groundwater for the proposed test location south of the Femme Osage Slough ranged from 2.5 mg/l to 27.3 mg/l for the same time period (MKF and JEG 1991b). Analytical results for bromide are very limited. Groundwater samples from four monitoring wells (MW-1018, MW-1019, MW-1021, and MW-1022) were analyzed for bromide in the first quarter of 1993. Bromide was not detected in excess of the contract detection limit of 0.38 mg/l. These analyses were performed as part of *The Environmental Monitoring Plan for Calendar Year 1993* (MKF and JEG 1992b), which provides for bromide analyses to be performed semi-annually on all wells in the study area. Additional analyses of chloride and bromide will be performed as part of the test procedure to statistically evaluate background concentrations prior to tracer introduction. Tracers will be introduced at sufficiently large concentrations to allow for distinction from background concentrations.

Figure 7-9 schematically illustrates the test configuration. In general, the tests are performed as follows:



NOT TO SCALE

TYPICAL TRACER TEST CONFIGURATION

FIGURE 7-9

REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/QY/030/0393	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 3/93	

- Estimates of the ground water flow velocity in the vicinity of the test locations will be made from results of slug tests, measurements of the local hydraulic gradient, and estimates of effective porosity.

- A grid of shallow and deep well points will be established. Grid spacing will be determined based on flow velocity estimates. The grid array will contain approximately 18 stations. Each station will consist of a well point placed a maximum of 1 m (3.28 ft) below the phreatic surface and a well point placed above the alluvium-bedrock contact.

- Water levels in the well points will be monitored on a daily basis for 10 days. Piezometric surfaces will be prepared from these data to obtain a more definitive grasp of the local flow field. If necessary, the grid array will be re-oriented to optimize the test with respect to transverse and longitudinal tracer transport. Background samples will be obtained from each grid array well point at three 72-hr intervals and analyzed for tracer constituents. Standard applicable procedures as described in ES&H Procedure 4.1.4, *Quality Control Samples for Aqueous and Solid Matrices: Definitions, Identification Codes, and Collection Procedures*, regarding blanks, duplicates, and quality control samples will be observed.

- Tracers will be introduced into the formation via one of the upgradient well points. Different tracers will be used for the shallow and deep networks. Tracers will be introduced on a daily basis for the period of the tests to simulate a constant source.

- Samples from each well point will be obtained daily using suction pumps, bailers, or other appropriate devices. One well volume will be purged prior to sample collection. The tests will last approximately 30 days.

Water generated as a result of tracer tests will be managed in accordance with WSSRAP Procedure RC-30.

Data analysis will proceed using general methods and techniques as described by Domenico and Schwarz (1990) for advective transport.

7.6 Hydrological Surveys

Hydrological surveys will be conducted over the period of investigation to obtain data regarding basic hydrologic characteristics and the hydrologic response of the study area to climatic influences. This activity will consist of the following elements:

- Topographic profiles of the Femme Osage Slough and Little Femme Osage Creek
- Groundwater elevation measurements
- Surface water stage measurements
- Precipitation measurements
- Flow measurements

7.6.1 Femme Osage Slough and Little Femme Osage Creek Profiles

Topographical surveys will be conducted of the Femme Osage Slough at approximately 11 locations, and of the Little Femme Osage Creek at five locations to determine sediment volumes. Figure 7-10 shows the survey locations. Survey locations correspond with sediment sampling locations prescribed in Section 8 of this plan. In general, each survey will be performed as follows (see Figure 7-11):

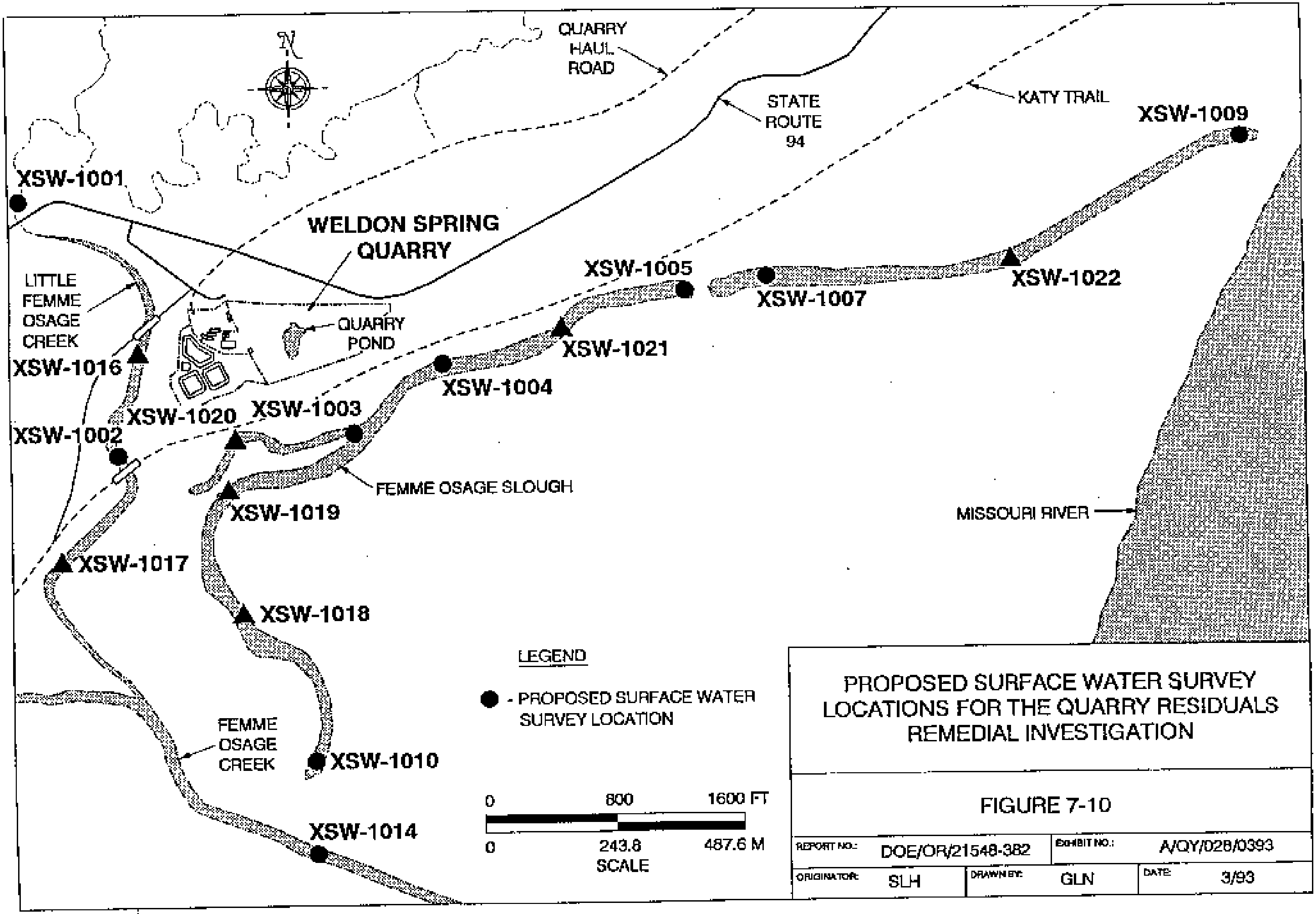
- Surface control points of known elevation will be established on the opposing banks at each location relative to average mean sea level (AMSL).

- A tag line of known increments will be placed between the control points so that positions between the control points may be established within 0.3 m (1 ft).

- Through the use of common surveying techniques, elevations for the following surfaces shall be established at 25 evenly spaced locations:

  - Surface 1 - Free water surface
  - Surface 2 - Initial water/sediment interface
  - Surface 3 - Bottom of upper sediment sequence

The bottom of the upper sediment sequence will be taken to be the depth to which a blunt probe such as a survey rod can be easily advanced by hand.



PROPOSED SURFACE WATER SURVEY LOCATIONS FOR THE QUARRY RESIDUALS REMEDIAL INVESTIGATION

FIGURE 7-10

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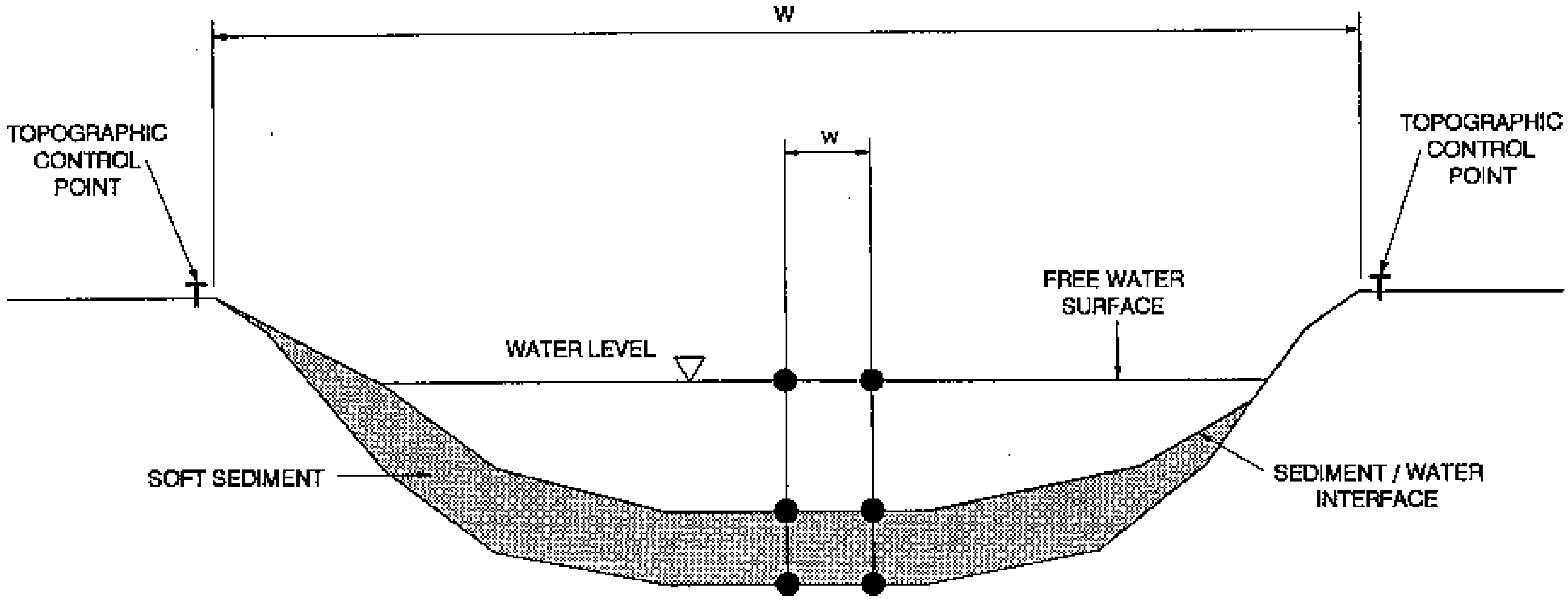

LEGEND

● - SURFACE MEASURING POINTS

W - TOTAL WIDTH OF SURFACE WATER BODY (BETWEEN CONTROL POINTS)

w - 0.04W

NOT TO SCALE

SURFACE WATER SURVEY METHODOLOGY			
FIGURE 7-11			
REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/PI/044/0393	
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Survey measurements will be maintained in accordance with industry standards as applied at WSSRAP for similar services. The information generated from these surveys shall be tabulated and plotted to represent the observed vertical and horizontal relationships at each section.

7.6.2 Groundwater Elevation Measurements

A combination of periodic and continuous groundwater elevation monitoring will be performed to assess the relationships between groundwater levels and precipitation, surface water stage, and groundwater pumping. Groundwater elevations are currently determined by the PMC on a monthly basis for all monitoring wells in the QROU study area as part of the site environmental monitoring program. Measurements are made to the nearest one hundreth of a foot (0.01) in accordance with ES&H Procedure 4.4.2 These data are typically plotted as hydrographs for each monitoring well. This program is scheduled to continue throughout the period of investigation. The additional wells installed as part of the QROU remedial investigation will be added to the water level measurement schedule.

Continuous groundwater elevation monitoring will be performed to evaluate discrete hydrologic responses which would not be reflected in the monthly measurement program discussed above. Continuous data will be collected using pressure transducers and data loggers in select monitoring wells for a minimum of 1 yr. Measurements will be made on a daily basis at each location. Table 7-3 lists the monitoring well and formation of interest for each location included in this program.

TABLE 7-3 Proposed Well Locations for Continuous Groundwater Elevation Monitoring

Well Number	Formation of Interest
MW-1033	Plattin Limestone
MW-1019	Alluvium
MW-1014	Alluvium
MW-1009	Alluvium
MW-1032	Kimmswick Limestone/Decorah Group
MW-1050	Plattin Limestone

Monitoring wells proposed for continuous groundwater elevation monitoring were selected to obtain information on vertical hydraulic gradients, as well as groundwater and surface water interaction, and climatic influences. Locations MW-1019 and MW-1033 will monitor groundwater in the alluvium and Plattin Limestone. These wells are collocated south of the Femme Osage Slough, thus allowing comparison with slough stage measurements.

Wells MW-1009 and MW-1014 (alluvium), MW-1032 (Kimmswick Limestone/Decorah Group) and MW-1050 (Plattin Limestone) are located north of the Femme Osage Slough where elevated concentrations of radionuclides and other contaminants are present in soil and groundwater (ANL 1993). A potential mechanism governing contaminant distributions in this area may be the migration of highly contaminated groundwater from the quarry pond through solutionally enlarged pathways in the Kimmswick Limestone to the fine-grained marginal alluvium located north of the Femme Osage Slough. It is conceivable that contaminated groundwater is preferentially discharged to the alluvium in this area. Attenuation mechanisms such as sorption and reduction may be active in this area as evidenced by the elevated concentrations of radionuclides in soil and groundwater. Monitoring of groundwater elevations in these wells during bulk waste removal may provide useful information regarding preferential transport in this area.

Aside from those monitoring wells listed in Table 7-3, monitoring wells MW-1004, MW-1034, and MW-1027 all monitor groundwater in the Kimmswick Limestone/Decorah Group. These wells are being monitored as part of the hydrologic monitoring program designed to support observational monitoring of bulk waste removal. In essence, groundwater levels in these wells will be monitored continuously to assess the effects of quarry pond dewatering associated with bulk waste removal. Drawdown information from these and other wells, along with pond discharge rates, may be useful in assessing the aquifer properties of the shallow bedrock and the degree of vertical and horizontal hydrologic continuity.

7.6.3 Surface Water Stage Measurements

Surface water stage for the Missouri River, Femme Osage Slough, Little Femme Osage Creek, and the quarry pond will be monitored on a daily basis during the period of investigation. Information regarding Missouri River stage will be obtained from the U.S. Geological Survey gaging station maintained at Hermann, Missouri, approximately 45 mi upstream of the site. The daily mean discharge of the Missouri River at Hermann with a 12-hr time lag has been used as a basis for estimating Missouri River conditions near the Weldon Spring quarry for previous hydrologic investigations because no significant streams discharge to the Missouri River between Hermann and the Weldon Spring quarry; also, there is about a 12-hr travel time between Hermann and the quarry.

Water level recorders will be placed to monitor stage for the lower reach of the Little Femme Osage Creek near the quarry, and for the Femme Osage Slough in the vicinity of the quarry. A catwalk or stilling well installation will be installed to perform stage monitoring in the Femme Osage Slough.

Discussions have been entered into with USGS personnel to determine the optimal locations and designs for these installations. The optimal locations and designs for these installations are being discussed with USGS personnel.

Bulk waste removal operations include continuous monitoring of the pond water level in the quarry. Discharge volume from the quarry pond for treatment will also be monitored to potentially assess drawdown response in monitoring wells. These data will be obtained to assist with the remedial investigation analysis.

Surface water stage data will be plotted relative to AMSL on hydrographs and used to help determine temporal relationships between surface water and groundwater.

7.6.4 Precipitation Measurements

Currently, a rain gauge is used to monitor precipitation at the quarry on a daily basis. This gauge has been operated since August 1991 and will be operated throughout the period of investigation. Operation of this gauge is standardized in accordance with ES&H Procedure 4.8.1, *Rain Gauge Manual Operation.*

7.6.5 Flow Measurements

Flow measurements of the Little Femme Osage Creek will be performed to assess the influence of upland drainage on the study area. Little Femme Osage Creek is a perennial stream in the QROU study area. It receives runoff and spring discharge from the north. It is the only active flowage in the study area aside from the Missouri River. Measurements will be made during low base flow and high base flow for a minimum period of one calendar year at a suitable location which is not susceptible to backwater influences from high stage of the Missouri River. USGS personnel will be consulted to establish a suitable measuring station and stage monitoring plan so that a rating curve (discharge versus stage) can be developed for this stream.

8 CONTAMINANT SAMPLING PROGRAM

This program has been developed to characterize the nature and extent of contamination in the Quarry Residuals Operable Unit (QROU) in support of the remedial investigations. The types, locations, and frequency of samples to be collected for Phase I, as well as the sampling protocol and procedures, are specified for each media (groundwater, surface water, sediment, and soil). No additional air monitoring other than that specified in the *Environmental Monitoring Plan for Calendar Year 1993* (EMP 1993) will be performed (see Section 8.5).

8.1 Sampling Objectives

Sampling efforts for the QROU have been developed using a phased approach. Phase I includes those activities performed and/or initiated prior to completion of bulk waste removal from the quarry proper, and Phase II sampling will begin once bulk waste has been excavated. Additional sampling plans will be developed to describe Phase II efforts once they can be adequately scoped.

This Contaminant Sampling Program (CSP) addresses Phase I sampling for the area outside the quarry proper with the intent of obtaining the following information:

- Identification and verification of contaminant types and concentrations within soil, sediment, surface water, and groundwater
- Background concentrations of naturally occurring potential contaminants of concern (PCOC) in each media
- Temporal and spatial distribution of PCOC in each media
- Mean concentrations of PCOC in each media
- Coefficients of variation for PCOC

Phase I will be conducted in subphases (Phase IA and Phase IB) for surface water, sediment, and soil. Since groundwater activities are continual, Phase I has not been subdivided for groundwater sampling. The primary objectives of Phase IA are identification and verification sampling, and obtaining site-specific background concentrations for naturally occurring PCOC. After each subphase is complete, objectives for subsequent subphases will be refined. After Phase IA, a report will be issued that includes data interpretation, reevaluation of the data quality objectives (DQOs), and refinement of the sampling efforts for Phase IB, if necessary.

With a phased approach, results from initial sampling (Phase IA) along with results from other Project Management Contractor (PMC) studies will be used to direct investigations during subsequent sampling during Phase I. Subsequent investigations will be aimed at further characterizing those areas where additional information is needed, where criteria established in the DQO process have not been met or where additional information is needed in order to assess the feasibility of remedial actions if such actions are deemed necessary. An advantage of a phased approach is that subsequent sampling may not be necessary; also, if additional information is required, then statistically based designs may be appropriate for areas identified during initial sampling. These efforts will require redefining sampling units into smaller areas in order to optimize sampling efforts. Data gathered during each phase may be used to optimize further characterization efforts for areas outside the quarry proper.

Information outlined in this plan is subject to change as additional information is acquired for the study area. If sufficient data are collected after a phase of sampling to support the use of statistical procedures for design of subsequent sampling efforts, then the scope of this program will be revised.

Data from historical investigations have been compiled and discussed in detail in the draft Work Plan (ANL 1993); therefore, this information is not presented in this plan.

8.2 Sampling Parameters and Field Measurements

The chemical and radiological PCOC along with other pertinent parameters and field measurements are discussed in Sections 8.2.1 and 8.2.2, respectively.

8.2.1 Chemical and Radiological Contaminants

Based upon historical investigations for all media, on routine monitoring of groundwater and surface water, and on contaminant persistence and mobility information, the chemical and radiological PCOC were identified in the draft Work Plan for the QROU (ANL 1993). The chemical PCOC were identified as metals, inorganic anions, and nitroaromatic compounds (ANL 1993). The radiological PCOC are actinium-227 (Ac-227), lead-210 (Pb-210), protactinium-231 (Pa-231), radium-226 (Ra-226), radium-228 (Ra-228), radon-222 (Rn-222), thorium-230 (Th-230), thorium-232 (Th-232), uranium-235 (U-235), and uranium-238 (U-238) (ANL 1993). This list is preliminary and subject to modification as additional information is acquired. Sampling during Phase IA will be performed in order to verify the presence or absence of various chemical classes and radiological constituents, to obtain media-specific background information, and to refine the PCOC list.

The PCOC list will be based in part on results of previous studies. Not all historical data can be verified/validated, but they were used in a qualitative sense to establish this preliminary list. Where appropriate, previously collected data will be submitted to the verification/validation process (see Section 11.3), and additional investigations identified in this sampling plan will assist in confirming or denying previous observations.

Sampling to identify and verify contaminant types and concentrations will be addressed during Phase IA. This includes sampling for chemical compounds and radiological constituents that are not suspected as being present but grounds for elimination from further consideration must be established. In most cases, confirmatory sampling will be accomplished by analyzing for the Target Compound List (TCL) (see Appendix A), nitroaromatic compounds and radiological constituents. In addition, analyses for geochemical parameters and field measurements, which are not primary components of the verification program, will be performed in order to examine the entire system and the different parameters that may influence contaminant mobility and migration. Table 8-1 lists the parameters that will be analyzed for each of these general categories. Throughout the text, reference will be made to these general categories and any exceptions or deviations from the parameters listed in Table 8-1 will be noted.

The additional information acquired during Phase IA will be used to refine the preliminary PCOC list. The criteria for refining the PCOC are frequency of occurrence, current or future risk, media type, location, concentration levels, historical information, background concentration, data obtained from other media, and DQO criteria. Documentation supporting the refinement of the PCOC list will be provided in the Phase IA report.

8.2.2 Other Pertinent Parameters and Field Measurements

In addition to the list of PCOC, parameters will be identified which will assist in assessing the potential migration and mobility of contaminants within the area. Analyses for various geochemical parameters may be necessary to examine potential redox reactions, ion speciation, system parameters, etc., which may be important in evaluating geochemical transport phenomena. Routine surface water and groundwater field measurements include temperature, pH, and specific conductance (SC) (MKF and JEG 1992b). Additional field measurements of dissolved oxygen (DO), water level, Eh, and laboratory measurements of total suspended solids (TSS) and total dissolved solids (TDS) may be determined along with PCOC.

TABLE 8-1 Categories and Parameters for Sampling and Analysis

Category	Parameters
TCL	VOCs, semi-VOCs, pesticides/PCBs, TCL metals
TCL metals	Al, As, Ba, Be, Ca, Cd, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Ni, K, Se, Ag, Na, Sb, Tl, V, Zn, cyanide (also include Mo and Li)
Nitroaromatic compounds	1,3,5-trinitrobenzene, 1,3-dinitrobenzene, 2,4,6-trinitrotoluene (2,4,6-TNT), 2,4-dinitrotoluene (2,4-DNT), 2,6-dinitrotoluene (2,6-DNT), nitrobenzene
Radiological constituents	Gross alpha, gross beta, total uranium, Ra-226, Ra-228, Th-228, Th-230, Th-232, isotopic uranium, Pb-210, and radon
Geochemical parameters	Br, Cl, F, Fe^{+2}, P, SiO_2, Sr, sulfide, NO_2, NO_3, alkalinity, total suspended solids (TSS), total dissolved solids (TDS), and total organic carbon (TOC)
Field measurements	Water level, temperature, pH, Eh, dissolved oxygen (DO), specific conductance (SC)

TCL = Target Compound List (see Appendix A)

8.3 Spatial and Temporal Sampling

Contamination within the media at or near the quarry is believed to have originated from contaminants that were placed there between 1942 and 1969 as a result of activities related to national defense. The magnitude and extent, both spatial and temporal, of chemical and radiological contamination has not been fully defined. However, previous studies confirm that contamination is present within the different media at and near the quarry.

The temporal (e.g., seasonal) and spatial (i.e., horizontal and vertical) distribution of contaminants will be addressed as part of Phase I sampling. The spatial distribution of contaminants within groundwater in the alluvium, Decorah Group, and Plattin Limestone has yet to be completely determined. Groundwater within the Decorah Group and Plattin Limestone due east of the quarry has not been fully characterized, and additional data are needed west and north of the quarry and south of the slough. If sufficient data are available, temporal variations in groundwater contaminant concentrations will be assessed based on trend analysis of monitoring data. Temporal variations of contaminant levels within surface water, primarily the slough, must also be investigated. Sediment within the Femme Osage Slough, Femme Osage Creek, and Little Femme Osage Creek also will be assessed. Chemical and radiological sampling and analysis of the soils near the quarry is also required to determine the spatial distribution of contaminants.

8.4 Environmental Monitoring Coordination

Related sampling efforts that are being undertaken by the PMC in the QROU study area are described in Section 4 and include the *Environmental Monitoring Plan for Calendar Year 1993* (EMP 93) (MKF and JEG 1992b) and the *Weldon Spring Quarry Supplementary Environmental Monitoring Investigations Sampling Plan* (SMP) (MKF and JEG 1992c). Where appropriate, these efforts and the information that will be obtained from these programs have been considered in developing the CSP to minimize redundancy of effort; thus, this CSP addresses data requirements not covered by these two plans.

8.5 Air Sampling

Routine air monitoring, performed as part of the site environmental monitoring program, continues to show that contaminants in the air are contained within the quarry proper (MKF and JEG 1993). Historically, radon levels and gamma radiation at the quarry have been elevated compared with background levels (ANL 1993); however, it is anticipated that as bulk wastes are removed, these levels should decrease (ANL 1993). Airborne radioactive particulates are not statistically different from background levels (ANL 1993). Monitoring activities are adequate at this time, and in this plan, additional air monitoring is not proposed outside the quarry. Current monitoring stations at the quarry perimeter will continue to monitor for radon, gamma radiation, and radioactive air particulates as outlined in the EMP 1993 (MKF and JEG 1992b). Data collected during routine air monitoring will be used as characterization data for the quarry residuals remedial investigation. However, if data indicate that air quality levels are changing, then additional air monitoring activities may be warranted. This is particularly important during bulk waste removal activities and the need to safeguard human health and the environment.

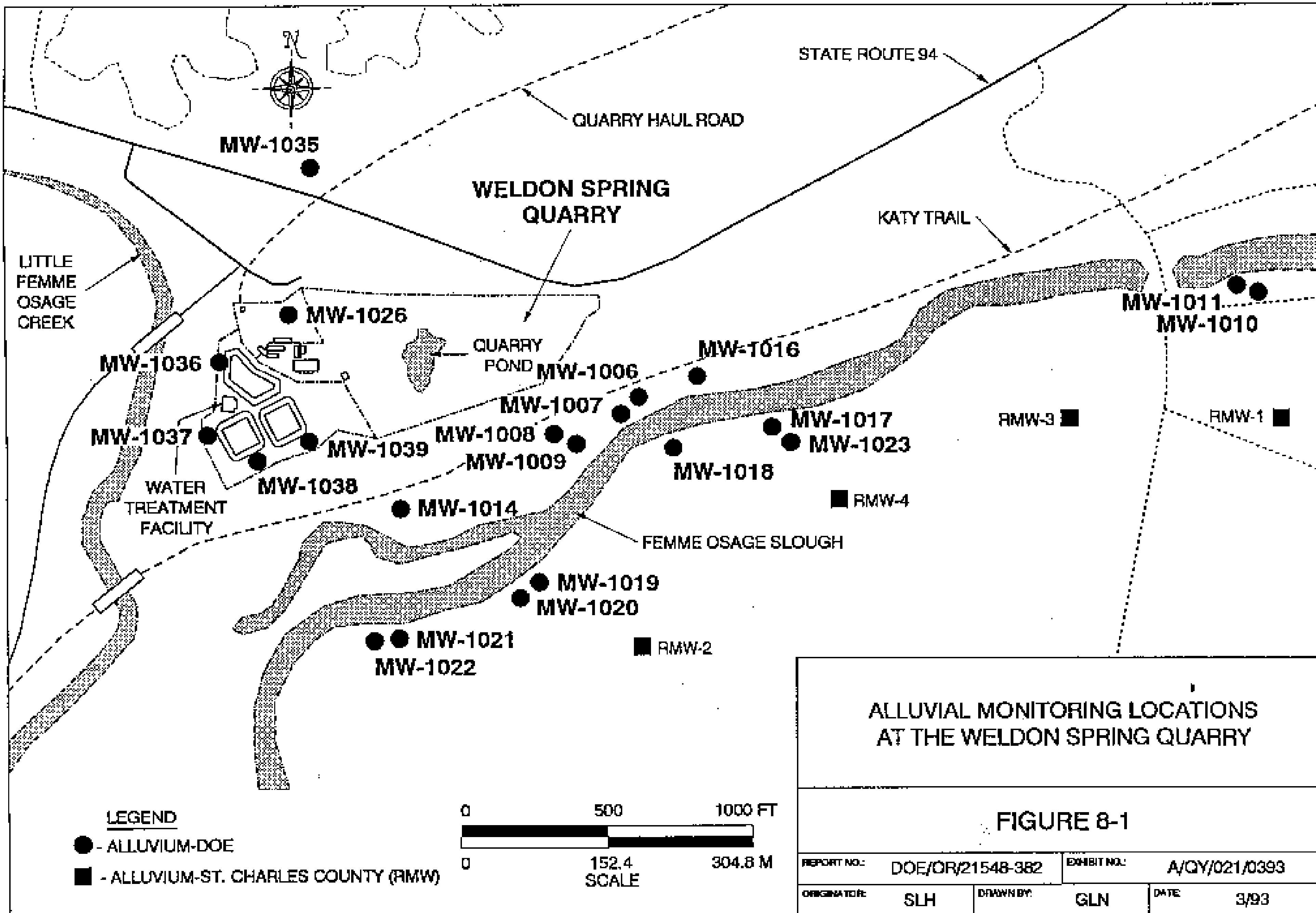
8.6 Groundwater Sampling

Phase I groundwater sampling efforts for quarry residuals characterization will combine activities from the WSSRAP EMP (MKF and JEG 1992b) and the SMP (MKF and JEG 1992c). Groundwater monitoring activities, which are currently being conducted by the PMC, are described in Tables 4-1, 4-2, and 4-3. Figures 8-1, 8-2, and 8-3 show the current groundwater monitoring wells. To support characterization efforts, additional analyses will be added to the EMP as outlined in Table 8-2. These additional analyses will occur during calendar year (CY) 1993. Unfiltered samples will be analyzed for volatile organic compounds (VOCs), semi-VOCs, and pesticides/polychlorinated biphenyls (PCBs) from nine wells. Analyses for geochemical parameters will be performed for those wells not originally slated for these analyses (see Table 8-2). Additional radiological constituents (Pb-210, radon, and isotopic uranium) will be analyzed in unfiltered samples from nine wells.

Information from these analyses; from other EMP 1993 groundwater monitoring activities; and from surface water, sediment, and soil sampling (after Phase IA) will be available for refining the PCOC list. Subsequent groundwater sampling characterization activities will be incorporated and/or coordinated, as appropriate, with monitoring efforts as outlined in the EMP.

8.6.1 Filtered/Unfiltered Samples

According to the *Risk Assessment Guidance for Superfund, Volume 1 Human Health Evaluation Manual* (EPA 1989), estimations of exposure concentrations should utilize data from unfiltered samples, and the remedial project manager (RPM) should be consulted prior to using data from filtered samples. Since historical data along with information gathered from activities specified in the EMP 93 will be used for characterization efforts, a comparison must be drawn between filtered and unfiltered samples. Data collected from filtered samples will provide additional geochemical information for modeling purposes. Based on this study, if a difference



ALLUVIAL MONITORING LOCATIONS
AT THE WELDON SPRING QUARRY

FIGURE 8-1

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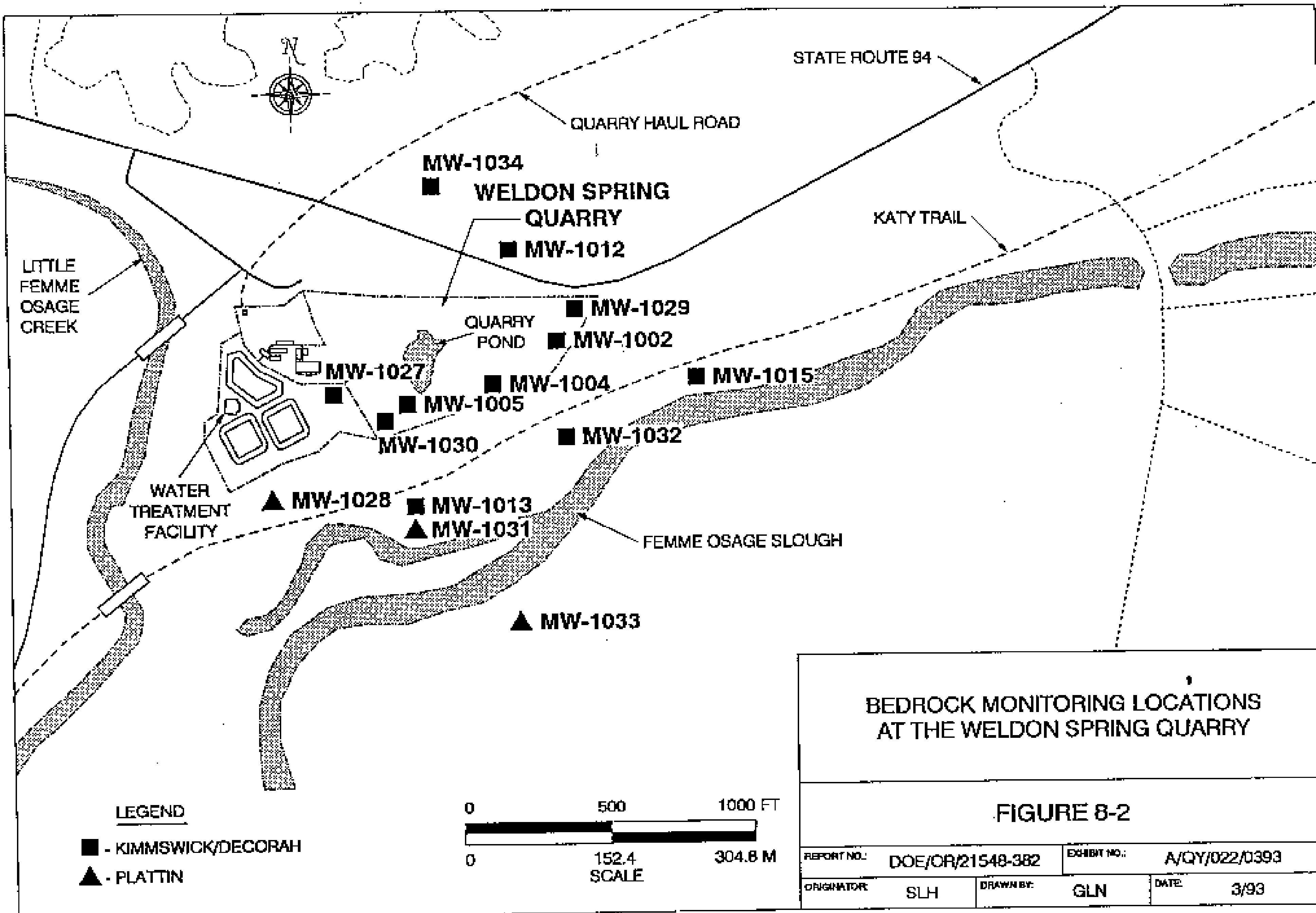

BEDROCK MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 8-2

REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/QY/022/0393
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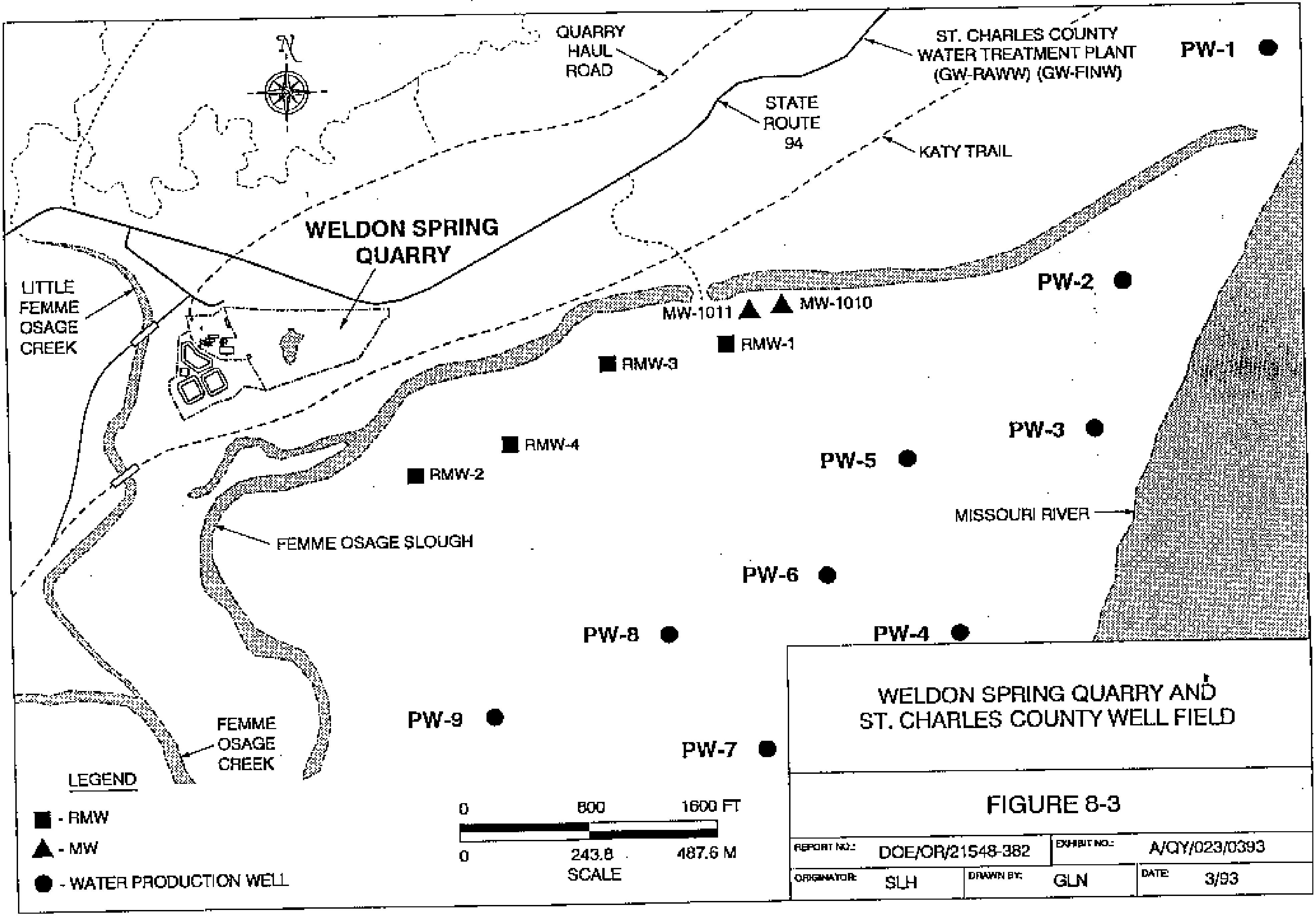

WELDON SPRING QUARRY AND ST. CHARLES COUNTY WELL FIELD

FIGURE 8-3

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TABLE 8-2 Additions to the WSSRAP EMP to Support Characterization Efforts

	Geochemical	VOCs, semi-VOCs, pesticides/ PCBs	Additional Radiological Constituents[a]
MW-1002		A	A
MW-1004	SA	A	A
MW-1005		A	A
MW-1006	SA		
MW-1007	A		
MW-1008	A	A	A
MW-1009	SA		
MW-1010	A		
MW-1011	A		
MW-1012	A	A	A
MW-1013			
MW-1014		A	A
MW-1015	A		
MW-1016	A		
MW-1017	SA		
MW-1018		A	A
MW-1019		A	A
MW-1020	A		
MW-1021			
MW-1022			
MW-1023	A		
MW-1024	A		
MW-1026	A		
MW-1027	A	A	A
MW-1028			
MW-1029	A		
MW-1030	A		
MW-1031			
MW-1032			

TABLE 8-2 Additions to the WSSRAP EMP to Support Characterization Efforts (Continued)

	Geochemical	VOCs, semi-VOCs, pesticides/ PCBs	Additional Radiological Constituents[a]
MW-1033			
MW-1034			

A Annually
SA Semi-annually

Geochemical Al, As, Ba, Be, Br, Ca, Cd, Cl, Cr, Co, Cu, F, Fe, Pb, Li, Mg, Mn, Hg, Mo, Ni, P, K, Se, Ag, Na, Sr, Sb, Tl, V, Zn, Fe^{+2}, NO_2, NO_3, SiO_2, sulfide, alkalinity, TDS, TOC, TSS

[a] Includes Pb-210, Rn-222, and isotopic uranium.

in constituent concentrations greater than 10% is noted between filtered and unfiltered samples, the issue of filtered/unfiltered samples will be addressed for subsequent monitoring activities.

The 0.45 μ filter has been adopted as defining "dissolved" as opposed to "particulate" matter (HEM 1989); therefore, historical groundwater samples were routinely filtered through a 0.45 μ membrane filter. Filtered groundwater samples will be collected for all parameters as part of the EMP 93 except for VOCs, semi-VOCs, pesticides/PCBs, and additional radiological constituents which will be analyzed in unfiltered samples. In an attempt to relate constituent concentration levels to background data for filtered/unfiltered samples, the Darst Bottoms alluvial wells will be included in this study.

Two sampling events to assess temporal differences are scheduled for CY 1993. Groundwater samples withdrawn from a subset of wells (Table 8-3) will be analyzed for radiological constituents (except isotopic U, Pb-210, and radon), geochemical parameters (which includes TCL metals), total uranium, nitroaromatics, and sulfate in both filtered (0.45 μ membrane filter) and unfiltered samples. Laboratory measurements of TSS and TDS will be taken in order to examine the quantity of particulate matter in relation to constituent concentrations. Routine field measurements will also be taken.

The subset of wells was selected based on 1992 monitoring data for total uranium, arsenic, and nitroaromatic compounds (Table 8-3). Wells were also selected based on

TABLE 8-3 Proposed Groundwater Wells for Filtered/Unfiltered Study

Well #	Formation/Group/Strata	Rationale for Selection	NF, 0.45[c]	Analyses[d]
North of Slough				
MW-1002	Decorah	Low U[a], N	NF, 0.45	R, G, U, SO_4, N
MW-1004	Decorah	High U[b], N	NF, 0.45	R, G, U, SO_4, N
MW-1006	Alluvium	High U, N	NF, 0.45	R, G, U, SO_4, N
MW-1009	Alluvium	Low U, As	NF, 0.45	R, G, U, SO_4, N
MW-1013	Alluvium	High U, N, As	NF, 0.45	R, G, U, SO_4, N
MW-1028	Decorah/Plattin	Low U, As	NF, 0.45	R, G, U, SO_4, N
MW-1031	Plattin	Low U	NF, 0.45	R, G, U, SO_4, N
South of Slough				
MW-1017	Alluvium	Low U, visible SS, As	NF, 0.45	R, G, U, SO_4, N
MW-1018	Alluvium	Low U, As	NF, 0.45	R, G, U, SO_4, N
RMW-2	Alluvium	Low U, As	NF, 0.45	R, G, U, SO_4, N
Darst Bottoms Alluvial Wells				
DB1D	Alluvium	U, As	NF, 0.45	R, G, U, SO_4, N
DB2D	Alluvium	U, As	NF, 0.45	R, G, U, SO_4, N
DB3S	Alluvium	U, As	NF, 0.45	R, G, U, SO_4, N

(a) Low U = [U] < 30 pCi/l
(b) High U = [U] > 500 pCi/l
(c) NF = not filtered: part of planned sampling
0.45 = filtered using 0.45 μ filter (no modifier 0.45 used for illustration purposes here)
(d) R = gross alpha, gross beta, Ra-226, Ra-228, Th-228, Th-230, Th-232
G = geochemical parameters (includes TCL metals)
U = total uranium
SO^4 = Sulfate
N = Nitroaromatic compounds

completion interval, location, and discussions with samplers concerning wells where visible suspended solids have been noted.

Filtration will take place in the field at the time of sample collection. Samples collected for nitroaromatic analyses will be filtered at the laboratory. The filtrate and the weighed solid residue on the filters will be analyzed to assess sorption of nitroaromatic compounds onto suspended solids. If nitroaromatics are not detected during the first sampling event (CY 1993), then this process will be eliminated during the second sampling.

8.6.2 Additional Groundwater Characterization

In addition to the aforementioned activities, monitoring wells will be drilled as part of this plan. Section 7 details the drilling activities and procedures as well as targeted physical data. Samples for background concentrations of constituents are addressed in Subsection 8.6.2.2.

8.6.2.1 Proposed Wells. Figure 7-1 illustrates the approximate location of the wells which are being proposed to determine the real and potential extent of contamination. Monitoring well designations should be considered tentative at this time. Table 7-1 lists, for each well, the general location, reason for installation, estimated total depth and formation monitored. During subsequent phases of the remedial investigation, additional wells may be drilled in order to further define the extent of contamination.

Initial groundwater characterization for these proposed wells will include analysis for TCL metals, total petroleum hydrocarbons, nitroaromatic compounds, radiological constituents (except Pb-210), sulfate, geochemical parameters, and field measurements (see Table 8-4).

The PCOC and pertinent parameter list may be developed before these wells are completed. If this is the case, these wells will be sampled monthly for the PCOC and pertinent parameters after initial characterization. Monthly sampling will be initiated in order to quickly establish baseline data for the PCOC and pertinent parameters. However, once results are received from initial characterization, the data will be reviewed to ensure that the PCOC and pertinent parameters list includes all necessary parameters. Sampling frequency will be evaluated at an appropriate time.

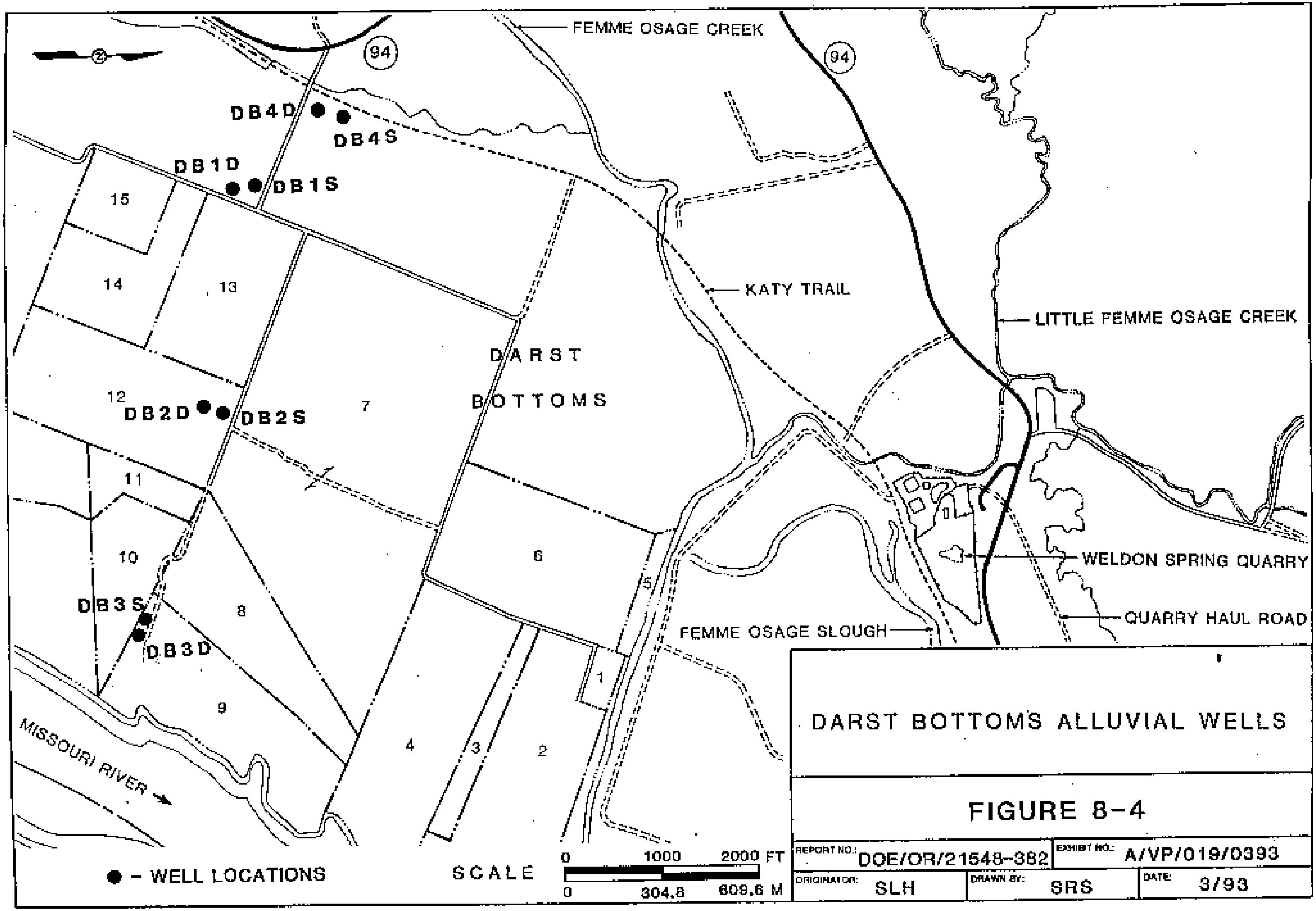
TABLE 8-4 Well Identification and Parameters for Initial Characterization of Proposed Groundwater Wells

Well ID	Parameters
MW-1047	TCL metals, TPHC, N, RAD, Field, G, SO_4
MW-1048	TCL metals, TPHC, N, RAD, Field, G, SO_4
MW-1049	TCL metals, TPHC, N, RAD, Field, G, SO_4
MW-1050	TCL metals, TPHC, N, RAD, Field, G, SO_4
MW-1051	TCL metals, TPHC, N, RAD, Field, G, SO_4
MW-1054	TCL metals, TPHC, N, RAD, Field, G, SO_4

(See Table 8-1 for parameters)
TCL Target Compound List
TPHC Total petroleum hydrocarbons
N Nitroaromatic compounds
Rad Radiological constituents (except Pb-210)
Field Field measurements
G Geochemical parameters
SO_4 Sulfate

8.6.2.2 Background Wells. Background alluvial groundwater samples will be collected from the Missouri River alluvium from some of the eight monitoring wells (four deep and four shallow) located in the Darst Bottoms between Defiance and Femme Osage Creek (see Figure 8-4). Previously collected data from these wells has been compiled and summarized in the draft Work Plan (ANL 1993). Previous sampling of these wells included analyses for TCL metals, nitrate, sulfate, alkalinity, and radiological parameters. Deep wells were analyzed twice, and shallow wells were sampled once, for these constituents. Additional information from these locations is needed to support characterization efforts.

Preliminary background alluvial data will be obtained from a one-time sampling of three deep wells (DB1D, DB3D, and DB4D) and two shallow wells (DB2S and DB3S). These wells were selected at random and will be analyzed for TCL metals, radiological constituents, sulfate, geochemical parameters, and field measurements. Subsequent sampling for PCOC and other pertinent parameters will be performed quarterly for 1 yr. The number of wells sampled and this frequency may be adjusted depending upon results obtained.



DARST BOTTOMS ALLUVIAL WELLS

FIGURE 8-4

REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/VP/019/0393
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Background data for bedrock groundwater (Decorah Group [MW-1052] and Plattin Limestone [MW-1053]) will be collected from wells that will be drilled north of the quarry off the quarry haul road (see Figure 7-1). Background bedrock well samples will be analyzed once for TCL metals, total petroleum hydrocarbons, radiological constituents, sulfate, geochemical parameters, and field measurements. Once these baseline analyses have been performed, sampling frequency will be established for PCOC and other parameters.

8.6.3 Sample Collection

Sampling of existing wells will be carried out by trained personnel in accordance with ES&H Procedure 4.4.1, *Groundwater Sampling*, using dedicated bladder pumps and/or PVC, Teflon, or stainless-steel bailers. According to procedure ES&H 4.1.4, equipment blanks are collected when nondedicated pumps (such as bailers) are utilized. The bailers are subsequently decontminated in accordance with procedure ES&H 4.1.3.Applicable Standard Operating Procedures (SOPs) are listed in Section 10.

All nondedicated sampling equipment will be decontaminated using a detergent solution and rinsing with deionized water to remove visible residue. Sampling equipment decontamination will be performed in accordance with ES&H Procedure 4.1.3, *Sampling Equipment Decontamination*.

Samples to be analyzed for volatiles will be collected with minimal agitation, filtration, or other activities that can volatilize contaminants. No head space will be left in the sample vessel by filling to form a negative meniscus. Samples collected for analysis of nitroaromatic compounds will be placed in amber glass and protected from direct ultraviolet radiation (sunlight).

Sample containers and preservation requirements are listed in ES&H Procedure 4.4.1. In addition to the list of containers presented in this procedure, sample containers will include 1- to 2-liter clear, wide-mouthed, glass containers for total petroleum hydrocarbons, and 2- or 2.5-liter jugs for semi-VOCs, pesticides, and PCBs. Preservatives will include sulfuric acid (H_2SO_4) for total petroleum hydrocarbons, nitric acid (HNO_3) for metals, and hydrochloric acid (HCL) for volatile organics. Additional preservatives are listed in ES&H Procedure 4.4.1.

Sample numbers will be assigned according to ES&H Procedure 4.1.1, *Numbering System for Environmental Samples and Sample Locations*. Sample labels will be completed in waterproof ink and will include site name and address, sample ID number, parameter or parameters to be analyzed, matrix, sampler or samplers, date sampled, filtration status, and sample preservation procedure used.

Sample chain of custody will be maintained in accordance with WSSRAP ES&H Procedure 4.1.2, *Chain of Custody*. All samples will be kept immediately after collection and during shipping at 4°C.

Filtration of groundwater samples is addressed in ES&H Procedure 4.5.8, *Water Sample Filtering*. Samples collected for analysis for VOCs, semi-VOCs, and pesticides/PCBs will not be filtered. During the study on the comparison of filtered versus unfiltered samples, those samples designated as unfiltered will be collected separately.

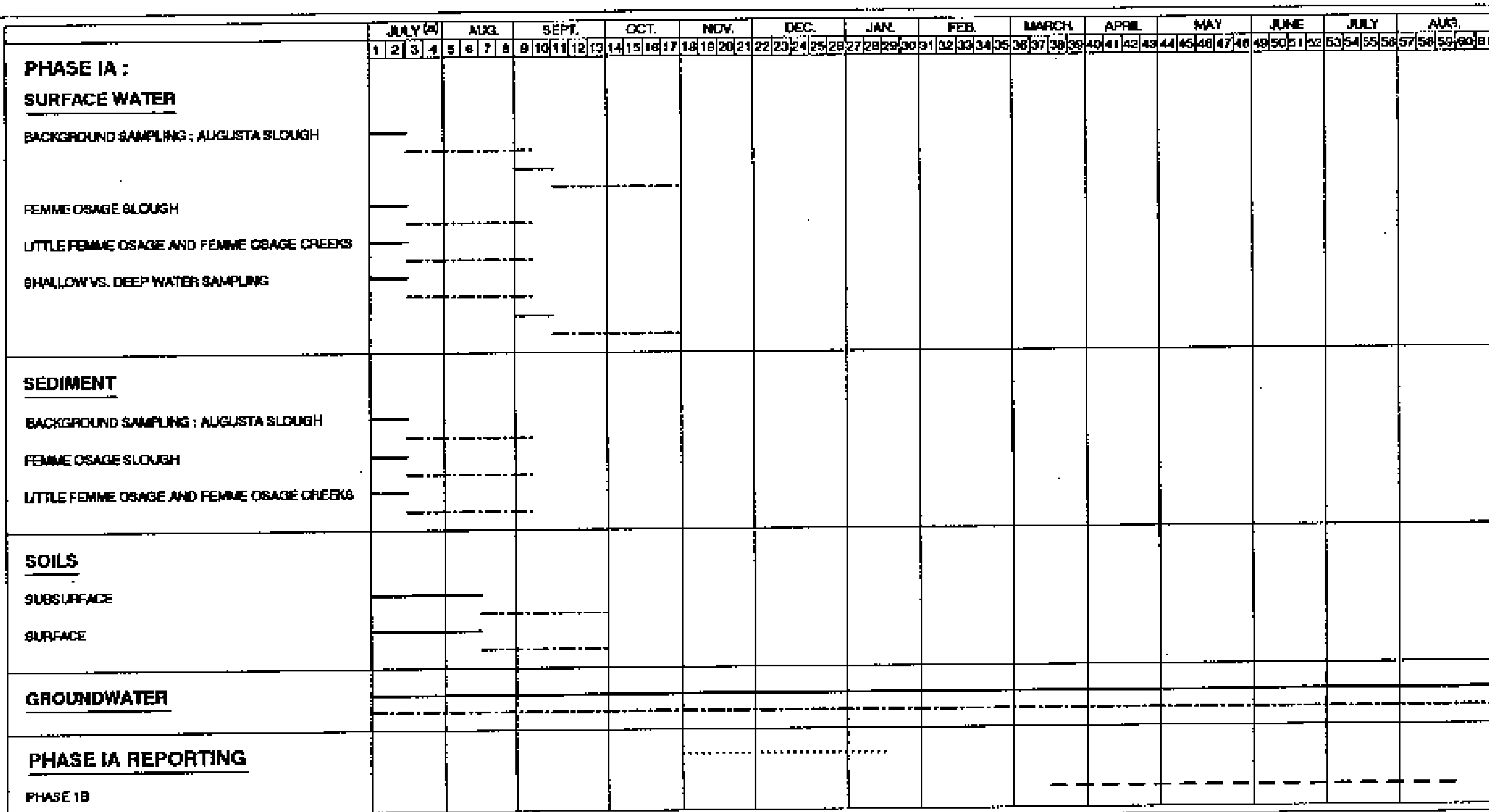
Field measurements of temperature, pH, Eh, DO, SC, and water surface elevation will be taken after purging but prior to sample collection, according to SOPs (see Section 10). Field logbooks and field data sheets must be completed according to ES&H Procedure 1.1.4, *Logbook Procedure*.

Quality assurance/quality control (QA/QC) samples have not been included in this discussion but will be collected according to the schedule presented in Section 10.

8.7 Surface Water Sampling

Besides routine surface water monitoring activities for CY 1993, which are outlined in the EMP 93 (MKF and JEG 1992b) (see Section 4.1), additional characterization efforts are necessary. The surface water characterization covered in the CSP uses a phased approach to optimize the gathering of information as outlined below.

For surface water sampling, Phase I has been divided into Phases IA and IB. Figure 8-5 illustrates the proposed schedule for each phase. The Femme Osage Slough is one sampling unit separated into an east and west section by the access road to the production well field. The Little Femme Osage and Femme Osage Creeks are combined into one unit. This phased approach is outlined below and applies to these sampling units.



LEGEND

- FIELD ACTIVITY
- LABORATORY ANALYSIS
- PHASE IA REPORTING
- PHASE IB

(a) SCHEDULE ASSUMES THAT FIELD ACTIVITIES BEGIN JULY 1, 1994

SCHEDULE FOR PROPOSED SAMPLING

FIGURE 8-5

REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/PI/068/0493	
ORIGINATOR: SLH	DRAWN BY: GLN	DATE: 11/02/93	

Phase IA:

- Background sampling in Augusta Slough
- Sampling for TCL in Femme Osage Slough
- Sampling in Little Femme Osage and Femme Osage Creeks
- Evaluation of shallow vs. deep water sampling in Femme Osage Slough
- Refining PCOC list

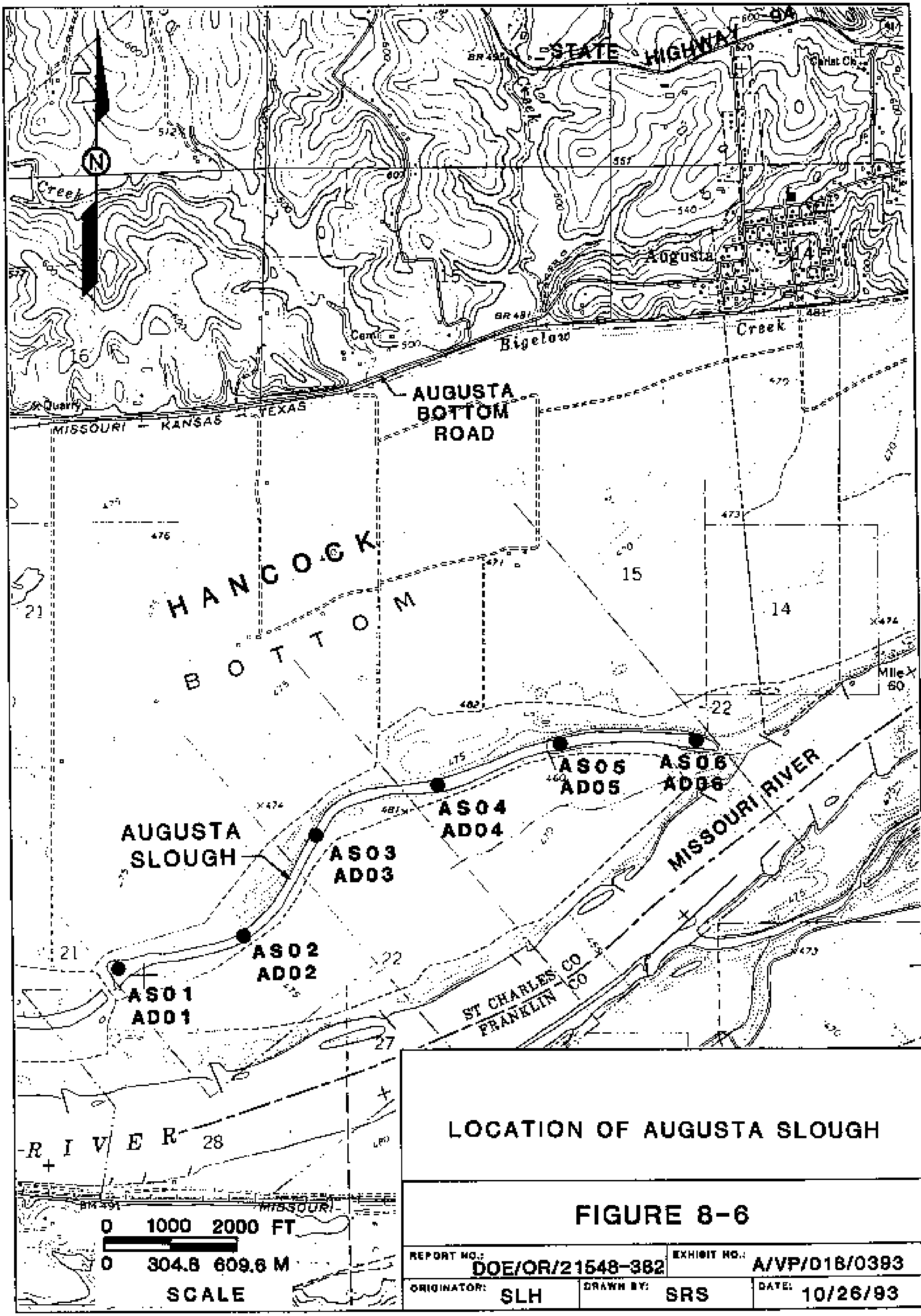
Phase IB: (Temporal Sampling)

- Biweekly sampling for PCOC and pertinent parameters for 16 weeks (9 sampling events)
- Evaluation of sampling frequency at specified times
- Evaluation of PCOC and other pertinent parameters at Augusta Slough
- Evaluation of need for additional samples

8.7.1 Phase IA

8.7.1.1 Background Sampling. Background sampling will be performed in the eastern end of the Augusta Slough, which is located in the Hancock Bottoms near Augusta, Missouri. Augusta is approximately 9.5 mi upstream from the quarry proper. The Augusta Slough was selected for background sampling because the slough environment is similar to that of the Femme Osage Slough, and it is out of the influence of the Weldon Spring quarry. During initial sampling, sediment type, vegetation, and other physical characteristics will be evaluated and compared with the Femme Osage Slough to assess suitability as a background location. This slough is divided into two segments by a rock dike. Water tends to remain in the eastern section of the slough year-round, whereas the western section tends to dry out during the summer months. Therefore, the eastern section has been selected for background sampling. The Augusta Slough location and sampling sites are illustrated in Figure 8-6.

Background sampling will take place twice during Phase IA and once during Phase IB to examine temporal variations. Sampling locations will be approximately equally spaced; Table 8-5 lists the parameters that will be measured for each location. During the first sampling, samples from the six locations will be analyzed for TCL metals, sulfate, radiological



LOCATION OF AUGUSTA SLOUGH

FIGURE 8-6

REPORT NO.: DOE/OR/21548-382
EXHIBIT NO.: A/VP/018/0393
ORIGINATOR: SLH
DRAWN BY: SRS
DATE: 10/26/93

TABLE 8-5 Proposed Surface Water Sampling of the Augusta Slough

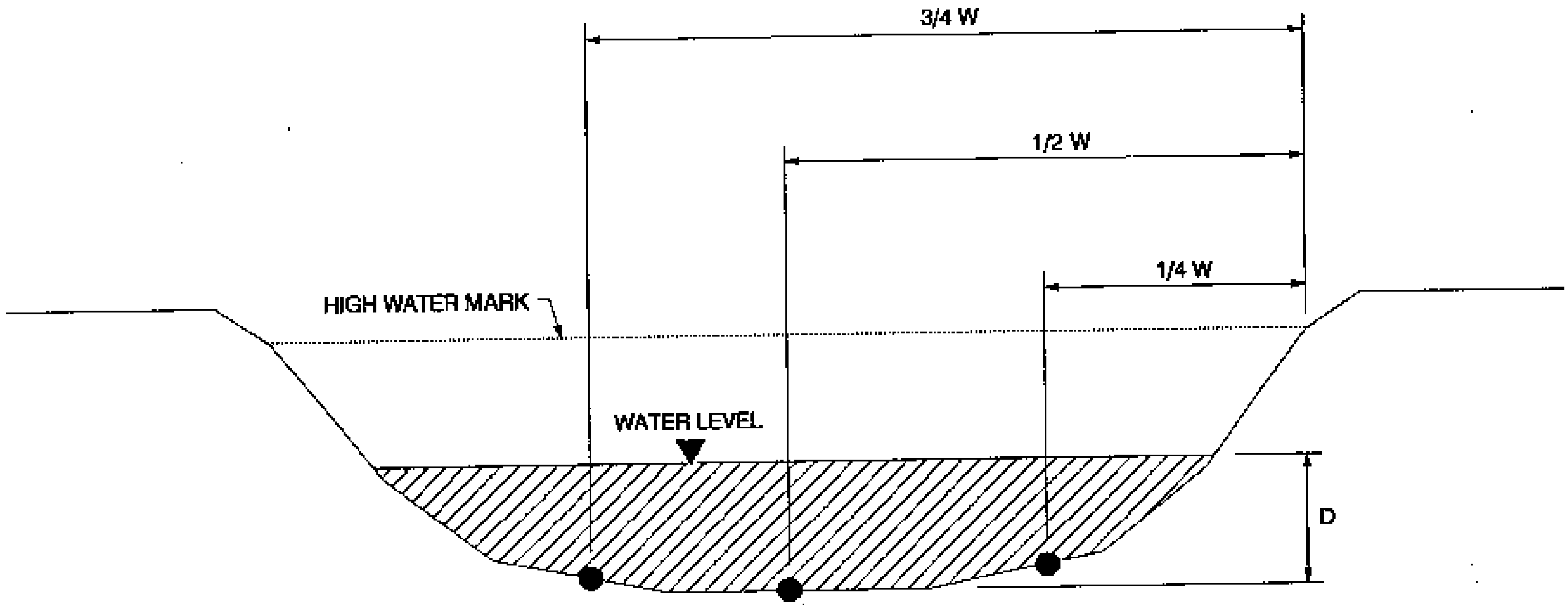
Location ID#	Phase IA	Phase IB
AS01	TCL metals, SO_4, Rad, G, Field	PCOC, Field, + additional pertinent parameters
AS02	TCL metals, SO_4, Rad, G, Field	PCOC, Field, + additional pertinent parameters
AS03	TCL metals, SO_4, Rad, G, Field	PCOC, Field, + additional pertinent parameters
AS04	TCL metals, SO_4, Rad, G, Field	PCOC, Field, + additional pertinent parameters
AS05	TCL metals, SO_4, Rad, G, Field	PCOC, Field, + additional pertinent parameters
AS06	TCL metals, SO_4, Rad, G, Field	PCOC, Field, + additional pertinent parameters

(See Table 8-1 for parameters)
RAD Radiological Constituents (except Pb-210 during second sampling event)
G Geochemical Parameters
FIELD Field Measurements
PCOC Potential Contaminants of Concern
TCL Target Compound List
SO_4 Sulfate

constituents, hardness, and geochemical parameters. In addition, pH, Eh, DO, temperature, SC, and surface water stage will be evaluated in the field. Approximately 1.5 mo after collection of the first samples, samples from each location will be analyzed for TCL metals, sulfate, radiological constituents (except Pb-210), and geochemical parameters. Samples will be taken at approximately 0.5 D (ft) measured from the water surface (D = water depth) (see Figure 8-7). Temperature, pH, Eh, DO, SC, and surface water stage will also be measured. Background sampling during Phase IB will be discussed in Section 8.7.2.

8.7.1.2 Femme Osage Slough. Proposed surface water sampling locations are shown in Figure 8-8. Surface water locations that are routinely sampled as part of the site environmental monitoring program are shown by a solid dot; additional locations proposed for the remedial investigation are represented by a solid triangle. Location numbers should be considered tentative at this time.

As part of the EMP 1993, nitroaromatics, radiological constituents (gross alpha, gross beta, Ra-226, Ra-228, Th-228, Th-230, Th-232), hardness, NO_3 and SO_4 will be analyzed annually; total uranium will be analyzed bimonthly. In addition to this information, which



STREAM OR SLOUGH CROSS SECTION

● - SAMPLE POINT

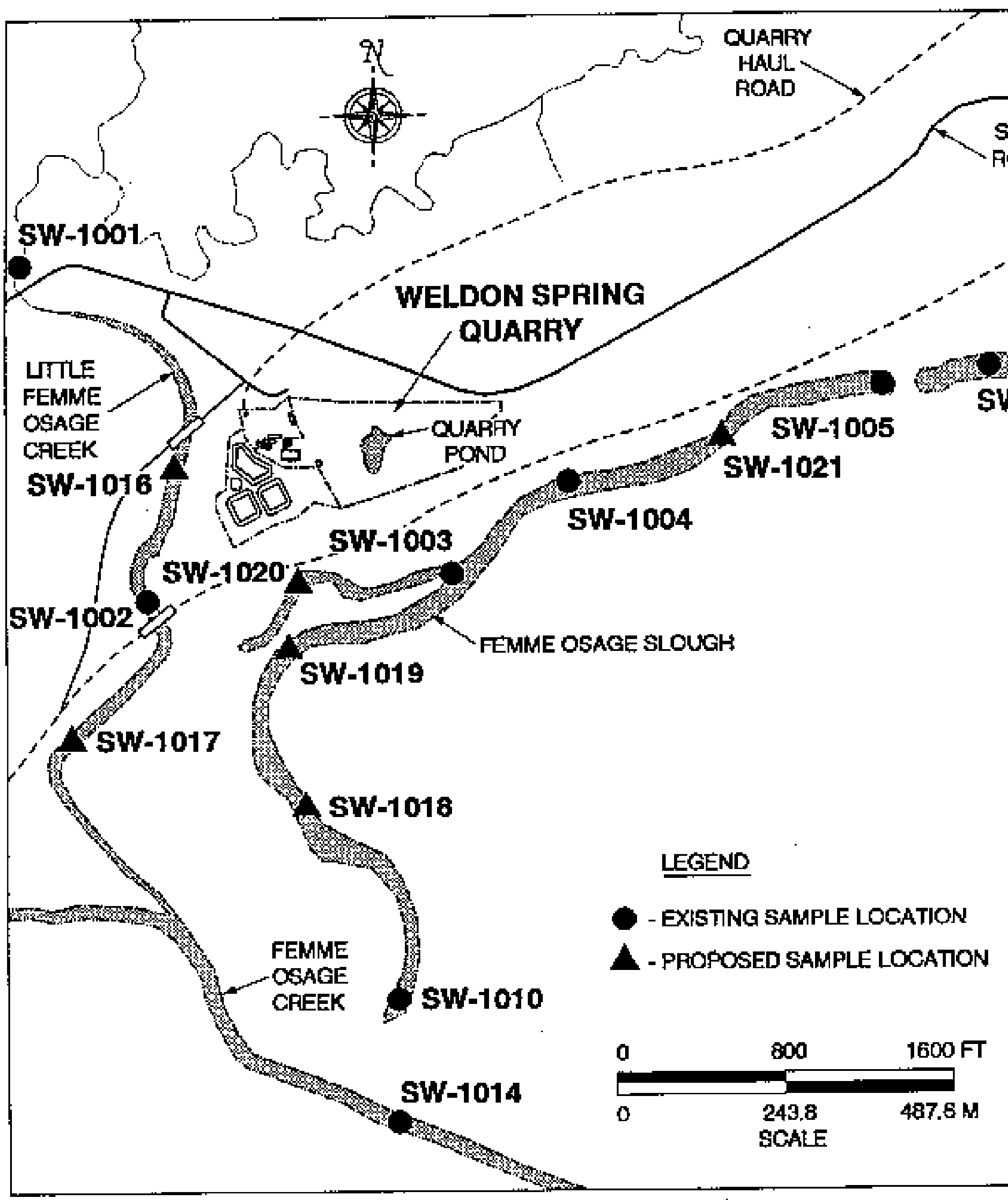
NOTE : EQUAL AMOUNT OF SAMPLE FROM EACH POINT IS HOMOGENIZED IN DECONTAMINATED STAINLESS STEEL CONTAINER.

NOT TO SCALE

PROPOSED SAMPLING POINTS FOR SLOUGH OR CREEK SEDIMENT SAMPLES

FIGURE 8-7

REPORT NO.:	DOE/OR/21548-382			EXHIBIT NO.:	A/PI/036/0393
ORIGINATOR:	SLH	DRAWN BY:	GLN	DATE:	10/26/93



PROPOSED SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 8-8

REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/QY/018/0393	
ORIGINATOR: SLH	DRAWN BY: GLN	DATE: 10/26/93	

will be used to support characterization efforts, samples from four locations in the Femme Osage Slough will be analyzed for TCL, Pb-210, radon, isotopic uranium, geochemical parameters, and field measurements. Table 8-6 lists the proposed sample locations and parameters for the analyses. Sampling locations were selected based on their proximity to the quarry proper, and include locations SW-1003, SW-1004, and SW-1020 in the eastern end of the slough and SW-1007 in the western end. If SW-1020 is dry at the time of sampling, SW-1021 or SW-1019 will be substituted. Since analyses will include volatiles, discrete samples will be taken at a depth of approximately 0.5 D (ft) (Figure 8-7).

8.7.1.3 Little Femme Osage and Femme Osage Creeks. Samples will be taken from SW-1001 and SW-1002 in the Little Femme Osage Creek and from SW-1014 in the Femme Osage Creek (Figure 8-8) in order to determine TCL metals, radon, isotopic uranium, geochemical parameters, and field measurements. Sample depth will be approximately 0.5 D (ft) (Figure 8-7). If VOCs, semi-VOCs, pesticides/PCBs, or Pb-210 are detected in groundwater near the creeks, a total or partial TCL analysis and/or analysis for Pb-210 will be performed.

8.7.1.4 Shallow vs. Deep Water Sampling. To assess potential stratification of contaminants within the Femme Osage Slough, a brief evaluation of shallow vs. deep water samples will be performed. Since seasonally stagnant conditions have been observed at the slough, stagnant zones caused by density differences or differences in mixing between deep and shallow water levels should be evaluated. Wind effects at the surface of the water may induce some mixing, which would not be observed at depth.

Locations were selected at random, and this evaluation will involve two sampling events at three locations (SW-1003, SW-1019, and SW-1021) in the western section of the slough and two locations (SW-1007 and SW-1022) in the eastern section. Two sampling events will be used in order to examine any temporal variation. As part of the hydrogeologic investigations sampling program described in Section 7, cross sections of the slough will be developed corresponding to the locations of surface water samples (see Section 7.6.1). Based on these cross-sections, samples will be taken at depths of approximately 0.1 D (ft) and 0.8 D (ft) (see Figure 8-7). Sampling techniques are discussed in Section 8.7.3. Unfiltered samples will be analyzed for arsenic, barium, zinc and total uranium. These metals were consistently detected at all locations during ecological monitoring of surface water. Other parameters which will be measured include surface water stages, TSS, TDS, alkalinity, pH, Eh, DO, SC, and

TABLE 8-6 Proposed Surface Water Sampling in Femme Osage Slough

SW Location #	Section of Slough	Phase IA	Phase IB (Biweekly Sampling)
SW-1003	East	TCL, Field, G, Pb-210, radon, isotopic uranium	PCOC, Field, and pertinent parameters
SW-1004	East	TCL, Field, G, Pb-210, radon, isotopic uranium	PCOC, Field, and pertinent parameters
SW-1005	East		PCOC, Field, and pertinent parameters
SW-1007	West	TCL, Field, G, Pb-210, radon, isotopic uranium	PCOC, Field, and pertinent parameters
SW-1009	West		PCOC, Field, and pertinent parameters
SW-1010	East		PCOC, Field, and pertinent parameters
SW-1018	East		PCOC, Field, and pertinent parameters
SW-1019	East		PCOC, Field, and pertinent parameters
SW-1020	East	TCL, Field, G, Pb-210, radon, isotopic uranium	PCOC, Field, and pertinent parameters
SW-1021	East		PCOC, Field, and pertinent parameters
SW-1022	West		PCOC, Field, and pertinent parameters

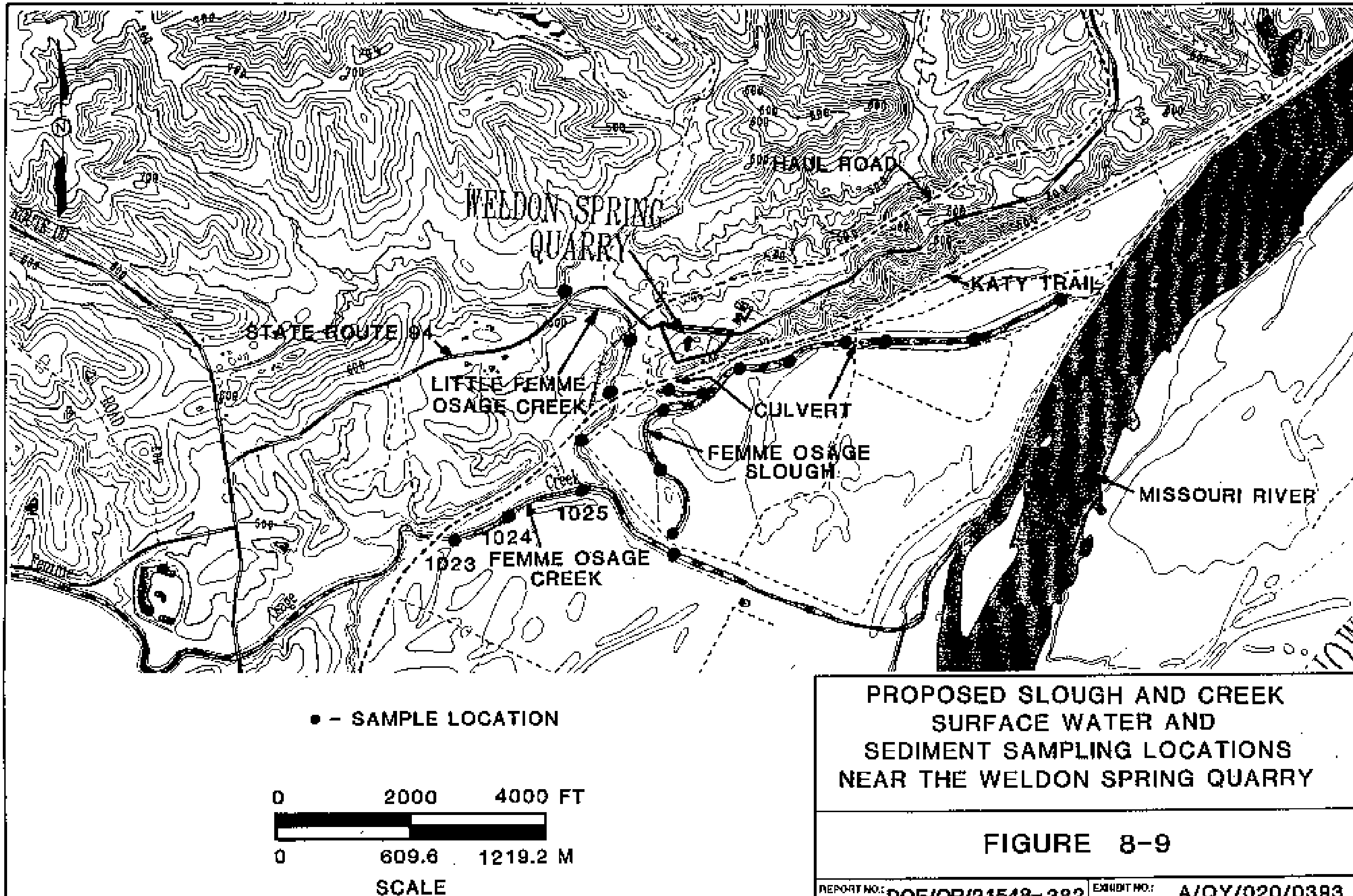
(See Table 8-1 for parameters)

TCL Target Compound List
Field Field Measurements
PCOC Potential Contaminants of Concern
G Geochemical Parameters

temperature. The effect of shallow versus deep water sampling will be evaluated and a decision will be made concerning sample depth for Phase IB sampling.

8.7.2 Phase IB

Phase IB will evaluate the temporal distribution of contaminants and will consist of biweekly sampling. The study period will span 16 weeks between the wet (March to August) and dry (September to February) seasons. Approximately nine sampling events will occur during this time. Based on analytical results, the sample frequency will be evaluated at an



PROPOSED SLOUGH AND CREEK SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 8-9

REPORT NO.: DOE/OR/21548-382		EXHIBIT NO.: A/QY/020/0393
ORIGINATOR: SLH	DRAWN BY: GLN	DATE: 3/93

appropriate time; the frequency may be changed or this phase may be terminated. Samples from each of the Femme Osage Slough, Little Femme Osage Creek, and Femme Osage Creek locations shown in Figure 8-8 will be analyzed for PCOC, field measurements (e.g., surface water stage, pH, Eh, DO, SC, and temperature), and additional pertinent parameters needed to analyze system dynamics. These analyses will provide an estimate of the mean concentrations and coefficients of variation for PCOC. During one sampling event, filtered and unfiltered samples will be analyzed from randomly selected locations to determine transport mechanisms for contaminants (i.e., whether contaminants are dissolved or sorbed onto suspended solids). In particular, temporal changes in surface water stage and its relationship to various parameters will be assessed.

Locations in the Augusta Slough will be evaluated for PCOC; field measurements such as water surface level, pH, Eh, DO, SC, temperature; and pertinent parameters such as TSS, TDS, and alkalinity (see Table 8-5). Six background samples (AS01, AS02, AS03 AS04, AS05, and AS06) will be taken (see Figure 8-6).

8.7.3 Sample Collection

Sampling of surface waters will be carried out by trained personnel in accordance with ES&H Procedure 4.3.1, *Surface Water Sampling*. Applicable SOPs are listed in Section 10. For surface and near surface locations, dip samples will be taken by immersing the sample container in the water body and allowing it to fill with water. For sampling at a desired depth, a peristaltic pump with Teflon tubing will be employed. This applies to samples for volatiles, which will be taken at approximately 0.5 D (ft). In the study of shallow- versus deep-water sampling, the peristaltic pump will be used to obtain samples at 0.1 D (ft) and 0.8 D (ft) (Figure 8-7). Decontamination of equipment between samples will be accomplished by following ES&H Procedure 4.1.3, *Sampling Equipment Decontamination*.

Samples to be analyzed for volatiles will be collected in such a manner to minimize loss of volatiles. No head space will be left in the sample vessel by filling to form a negative meniscus. Samples collected for analysis of nitroaromatic compounds will be placed in amber glass and protected from direct ultraviolet radiation (sunlight).

Sample containers and preservation requirements are listed in ES&H Procedure 4.3.1. In addition to the list of containers presented, containers include two 40-ml glass for volatiles, and 2- or 2.5-liter jugs for semi-VOCs, pesticides, and PCBs. Preservatives will include nitric acid (HNO_3) for metals and hydrochloric acid (HCL) for volatile organics. Additional preservatives are listed in ES&H Procedure 4.3.1.

Sample chain of custody will be maintained in accordance with ES&H Procedure 4.1.2. All samples will be kept at 4°C immediately after collection and during shipment.

Surface water samples will be unfiltered unless otherwise indicated. ES&H Procedure 4.5.8, *Water Sample Filtering*, will be followed when filtration is specified.

Field measurements of temperature, pH, Eh, DO, SC, and surface water stage will be taken prior to sample collection and recorded on the Surface Water Sampling Form. Water clarity and whether the sample was filtered/unfiltered will also be recorded on the field sheets. Field logbooks must be completed in accordance with ES&H Procedure 1.1.4.

QA/QC samples have not been included in this discussion but will be collected according to the schedule presented in Section 10. U.S. Department of Energy (DOE) authorized personnel will supervise field activities when appropriate.

8.8 Sediment Sampling

Some information regarding sediment within the Little Femme Osage Creek, Femme Osage Creek, and Femme Osage Slough exists; however, additional samples will be collected to verify this information and to determine the representative mean concentrations of contaminants. A detailed description of historical sediment data gathered in the areas outside the quarry proper has been compiled in the draft Work Plan for the QROU (ANL 1993). Prior to 1991, sediment data for the Little Femme Osage Creek and Femme Osage Slough consisted of limited analyses for radiological contaminants including total U, U-238, Ra-226, Th-230 and Th-232 (ORAU 1986, UNC 1988). Recent investigations conducted as part of an ongoing ecological monitoring program included analyses for a modified list of metals (As, Ba, Cd, Cr, Pb, Hg, Se, Ag, and Zn), total uranium, and nitroaromatic compounds (MKF and JEG 1992b). No sediment samples were analyzed for nitroaromatics in the Little Femme Osage Creek. Because of the limited amount of data available for sediments within the study area, additional samples will be taken.

Proposed sediment sampling locations are illustrated on Figures 8-9 and 8-10. Location numbers should be considered tentative at this time. Sediment locations correspond to surface water locations. When sediment samples are taken, field measurements for the surface water will be taken immediately prior to collection of each sediment sample. Discrete or grab samples will be collected from one location at the midpoint of the creek or slough. Composited samples will consist of equal aliquots of sediment from three points at each sample location (Figure 8-7).

In an attempt to obtain background information for the Femme Osage Slough, sediment samples will be taken from the Augusta Slough. Background sediment samples for the Little Femme Osage and Femme Osage Creeks will be taken from locations upstream of the quarry proper. Background sampling is included in the following discussion.

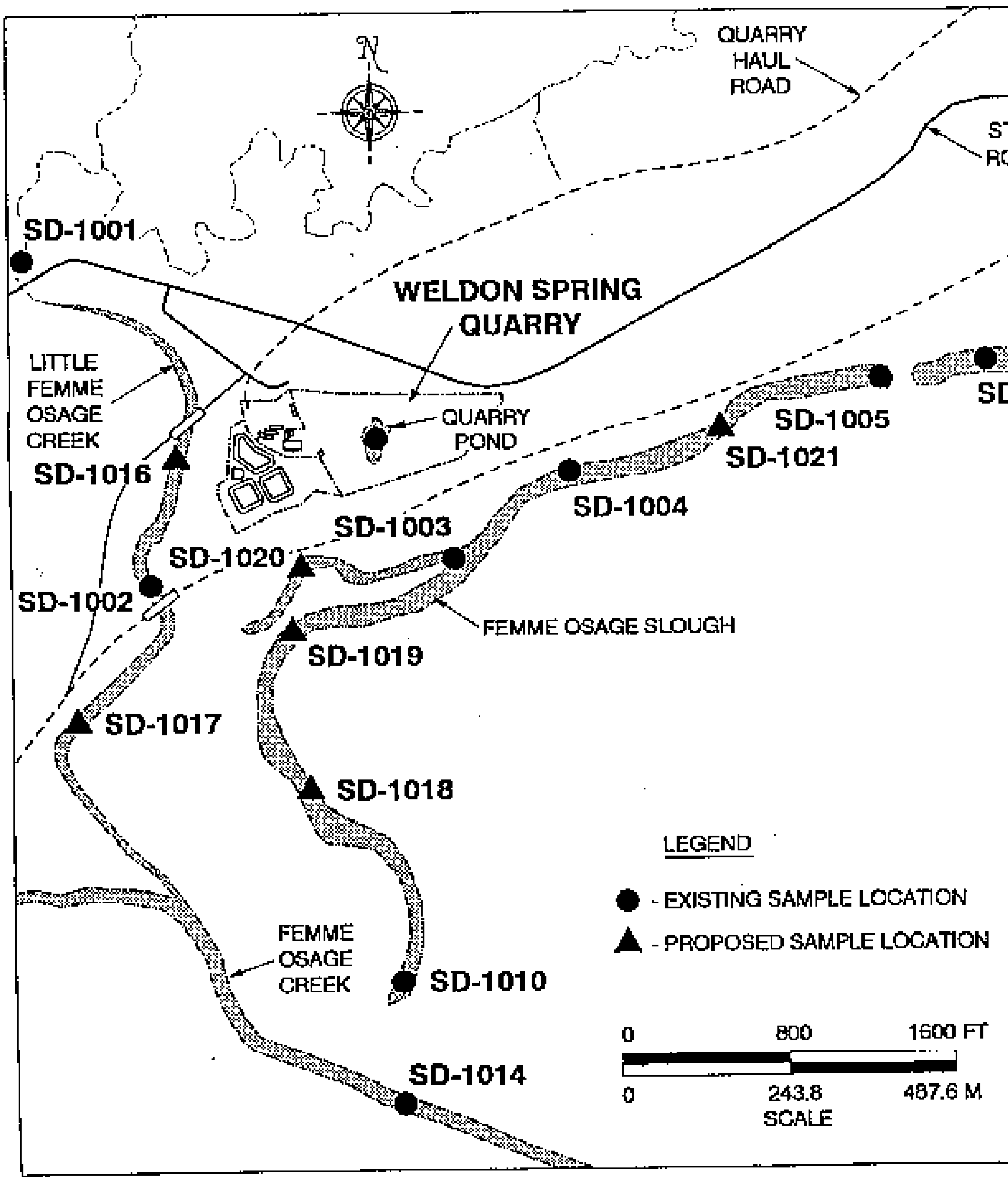
For sediment sampling, Phase I has been divided into Phases IA and IB. A tentative schedule for these phases is presented in Figure 8-5. This approach is outlined below and applies to all sediment sampling units (Femme Osage Slough and Little Femme Osage and Femme Osage Creeks).

Phase IA:

- Background sampling in Augusta Slough
- Background sampling in Little Femme Osage and Femme Osage Creeks
- Analysis of discrete samples from Femme Osage Slough for TCL
- Analysis of composite samples from Femme Osage Slough, Femme Osage Creek, and Little Femme Osage Creek for TCL metals, sulfate, nitroaromatics, radiological constituents, and some geochemical parameters
- Refining PCOC list.

Phase IB:

- Collection of composite samples at each location and analysis for PCOC and other specified parameters to assist in evaluating potential transport mechanisms



PROPOSED SEDIMENT SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY			
FIGURE 8-10			
REPORT NO.:	DOE/OR/21548-382	EXHIBIT NO.:	A/QY/019/0393
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- Air-drying of at least half of the samples and analysis of the -80 silt size fraction for PCOC, TOC, cation exchange capacity (CEC), and other parameters that can be used to assess the influence of size fraction, organic content, and CEC on geochemical processes

- Evaluation of the need for additional sampling including core sampling of sediment from the slough during Phase II activities

8.8.1 Femme Osage Slough

8.8.1.1 Phase IA. Sediment sampling for background data will take place in the Augusta Slough. Background sampling will be a one-time event with six composite samples (AS01 through AS06) analyzed for TCL metals, radiological constituents (except Pb-210, isotopic U, and radon), geochemical parameters (except alkalinity, Br, TSS, and TDS), sulfate, pH, and percent solids. Composite locations are illustrated in Figure 8-7.

Sampling in the Femme Osage Slough will consist of both discrete and composited samples. Discrete samples (SD-1003, SD-1004, SD-1019, SD-1007), taken at the slough's midpoint (Figure 8-7), will be analyzed for TCL, measurements of pH, and percent solids. This biased location selection was based on previous investigations. Four composite samples (SD-1021, SD-1022, SD-1020, SD-1018) will be analyzed for TCL metals, radiological constituents (except radon), nitroaromatics, geochemical parameters (except alkalinity, Br, TSS and TDS), sulfate, pH, and percent solids.

The PCOC list will be refined based on results from this sampling along with results from groundwater and surface water characterization efforts. In addition, results of sediment sampling from the ecological monitoring program will be used to refine the list of potential contaminants. If sampling indicates that a contaminant is absent within the sediment, but the contaminant is a PCOC in either surface water or groundwater, then the contaminant will be added to the PCOC list for future sediment sampling.

8.8.1.2 Phase IB. From each slough location shown in Figure 8-10, composite samples will be analyzed for PCOC and other pertinent parameters which will assist in evaluating transport mechanisms. In order to evaluate the influence of size fraction, TOC, and CEC on geochemical processes, at least half of the samples will be air-dried and the -80 silt fraction will be analyzed for PCOC, TOC, CEC and other parameters that can assist in assessing this influence.

Additional sampling needs and the possibility of drilling into the slough in order to collect sediment samples at depth during Phase II activities will be evaluated at the end of Phase I.

8.8.2 Little Femme Osage and Femme Osage Creeks

8.8.2.1 Phase IA. Four composited samples (see Figure 8-7), collected from SD-1001, SD-1002, SD-1017 (Little Femme Osage Creek), and from SD-1023 (Femme Osage Creek), will be analyzed for TCL metals, radiological constituents (except radon), geochemical parameters (except alkalinity, Br, TSS, and TDS), nitroaromatic compounds, sulfate, pH, and percent solids.

Information gathered from SD-1001, the northern-most point that will be sampled in the Little Femme Osage Creek, and from SD-1023, in the Femme Osage Creek, will be used for background information. Additional sampling of these points as well as two additional points (SD-1024 and SD-1025) in the Femme Osage Creek will be used as background information. The locations in the Femme Osage Creek were selected to provide data for a clay-rich environment.

The PCOC list will be refined based on results of composite sampling, background data, surface and groundwater monitoring data, and data from sediment sampling in the Femme Osage Slough.

8.8.2.2 Phase IB. Composited samples (see Figure 8-7) from the locations illustrated on Figure 8-9 and 8-10 will be analyzed for PCOC, field measurements, and other pertinent parameters. Half of the samples will be air-dried and the -80 silt size fraction will be analyzed for the PCOC, TOC, and CEC in order to evaluate the inter-relationship between the PCOC and size fraction, TOC, and CEC.

8.8.3 Sample Collection

Sediment samples will be collected by trained personnel according to ES&H Procedure 4.4.5. Applicable SOPs are listed in Section 10. A variety of sampling devices will be tested prior to final selection of the sampling device.

Discrete or grab samples will be collected from one location at the midpoint of the creek or slough. Composited samples will consist of equal aliquots of sediment from three points at each sample location (Figure 8-7). Samples will be composited in a decontaminated stainless-steel pan using a spatula. During compositing, any detritus (e.g., leaves, twigs) will be removed. A description of each sample (e.g., approximate grain size distribution, color, organic matter) will be made prior to and after compositing. Discrete samples will also be described. Some samples will be air-dried and sieved to determine the grain size distribution.

Decontamination of equipment between samples will be accomplished by following ES&H Procedure 4.1.3. Equipment will be washed with detergent and rinsed with clear water. Equipment will then be triple-rinsed with deionized water and air-dried.

Samples to be analyzed for volatiles will be collected as discrete (grab) samples with minimal agitation or other activity that could volatilize contaminants. No head space will be left in the sample container. Samples collected for analysis of nitroaromatic compounds will be placed in amber glass and protected from direct ultraviolet radiation (sunlight).

Sample containers for metal, nitroaromatic, inorganic anion, and semi-VOC analysis include separate 250-cc amber, wide-mouth bottles. For VOCs, two 40-ml vials will be used. Samples for radiological analysis will be collected in 500-cc amber, wide-mouth bottles. At this time, sample container sizes are preliminary and subject to change depending on the number of laboratories contracted for analyses and their specifications for required quantities.

Sample numbers will be assigned according to ES&H Procedure 4.1.1. Sample chain of custody will be maintained in accordance with ES&H Procedure 4.1.2. Immediately after collection and during shipment, samples will be kept on ice.

During sediment sampling, surface water field measurements will be taken according to ES&H Procedure 4.3.1 and recorded on the Surface Water Sampling Form. Field information from sediment sampling should be entered on Soil/Sediment Sampling Form 4.4.5.1 in accordance with ES&H Procedure 4.4.5. Field logbooks must be completed in accordance with ES&H Procedure 1.1.4.

QA/QC samples have not been included in this discussion but will be collected according to the schedule presented in Section 10. The deionized water blank is not applicable, and one field blank will be collected for every 20 samples (or one per sampling event). DOE authorized personnel will supervise field activities when appropriate.

Samples designated for analysis of the -80 silt size fraction will be discussed with the contracted laboratory. Procedures as well as sample quantity will be developed with the laboratory. For these samples, the required quantity will increase and the sample container size specified previously will be reevaluated.

8.9 Soil Sampling

Some information regarding soils within Vicinity Property 9 exists; however, additional samples will be collected to verify this information and refine the PCOC list. A detailed description of historical soil data gathered in the areas outside of the quarry proper has been compiled in the draft Work Plan (ANL 1993). Surface soil data for Vicinity Property 9 consisted of limited analyses for radiological contaminants including U-238, Ra-226, and Th-232 (ORAU 1986). Radionuclide analyses were also performed for four shallow borehole samples (ORAU 1986). Subsurface interval samples from other boreholes drilled in Vicinity Property 9 were analyzed for U-238 (UNC 1988). Limited chemical analyses were performed on samples collected during drilling of monitoring wells 1030, 1031, 1033 (south of the quarry proper) and 1034 (north of the quarry proper). Because of the limited amount of data available for soils within the study area, additional samples will be taken. Sampling efforts are discussed for three sampling units [soils north of Femme Osage Slough, soils south of Femme Osage Slough, and soils south-southwest of the Quarry Water Treatment Plant (QWTP)] along with discussion on background soil samples.

For soil sampling, Phase I has been divided into Phases IA and IB. A tentative schedule for these phases is presented in Figure 8-5. Phase IA for subsurface and surface soils is discussed in the following sections.

8.9.1 Subsurface Soils

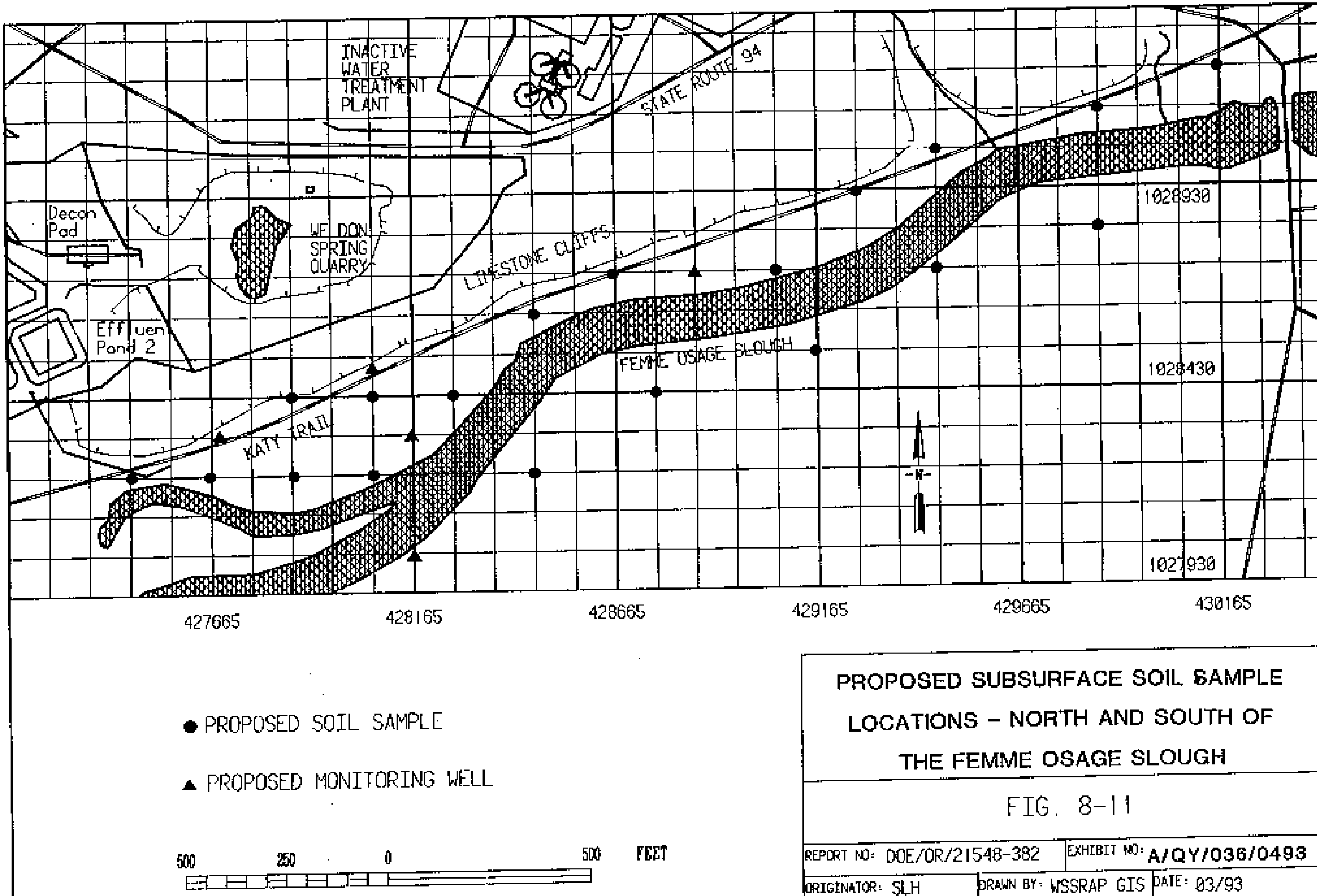
Subsurface soil samples will be collected to meet the following objectives.

- Identification and verification sampling to refine the PCOC list.
- Determination of the spatial contaminant distribution.
- Examination of Vicinity Property 9 as well as areas where boring samples have never been collected.
- Estimation of mean concentrations for PCOC and coefficients of variation.

Subsurface samples were located using a grid system with boreholes north of the Femme Osage Slough drilled at intervals of approximately 61 m (200 ft) (see Figures 8-11 and 8-12). Based on the grid and sample interval, points located on the quarry rim or in the Femme Osage Slough were eliminated or shifted slightly. Therefore, samples are not evenly spaced. Samples will also be collected during installation of monitoring wells (see Figures 8-11 and 8-12). Based on the grid system, proposed borehole locations near proposed monitoring wells were eliminated to avoid redundancy. However, if monitoring well installation does not occur during Phase IA, then these locations may be included. Any locations on the Katy Trail will be moved either north or south of the trail, depending on field conditions. If a location is unsuitable based on field inspection, the borehole will be relocated near the proposed location. In areas where visual inspection indicates that the soil has been reworked, the borehole will be relocated.

North and south of the Femme Osage Slough, 14 and five boreholes, respectively, will be drilled. In the area south-southwest of the quarry proper, three boreholes will be drilled.

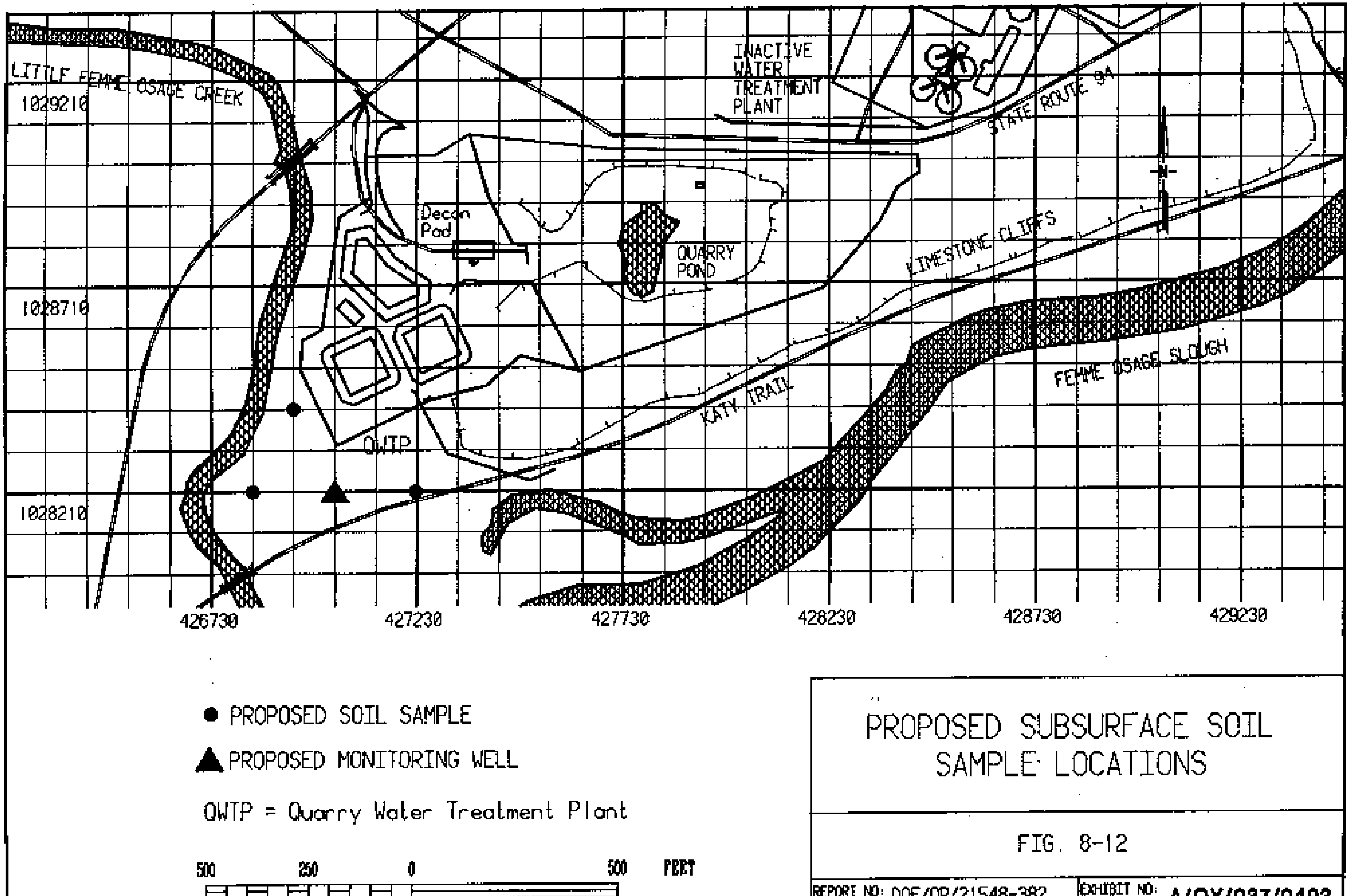
The proposal for subsurface sampling north of the Femme Osage Slough and south-southwest of the QWTP is to collect and composite borehole samples every 1.5-m (5-ft) interval of depth from ground surface to bedrock as long as the soil is relatively homogeneous. Because the area south of the slough is not thought to be contaminated, the composite interval may be increased within homogeneous soil. Additional samples north and south of the Femme Osage Slough may be collected or a change in composite length may occur based on soil type, soil unit



PROPOSED SUBSURFACE SOIL SAMPLE LOCATIONS – NORTH AND SOUTH OF THE FEMME OSAGE SLOUGH

FIG. 8-11

REPORT NO: DOE/OR/21548-382		EXHIBIT NO: A/QY/036/0493
ORIGINATOR: SLH	DRAWN BY: WSSRAP GIS	DATE: 03/93



PROPOSED SUBSURFACE SOIL SAMPLE LOCATIONS

FIG. 8-12

REPORT NO: DOE/OR/21548-382		EXHIBIT NO: A/QY/037/0493	
ORIGINATOR: SLH	DRAWN BY: WSSRAP GIS	DATE: 10/26/93	

thickness, soil strata, radiological scanning, or other parameters identified at the time of sampling. To provide a measure of variation for composite samples, duplicate composite samples will be prepared from separate samples at approximately 10% of the sample intervals. The borehole and intervals for duplicate samples will be selected randomly prior to sampling. If analyses will include volatiles, then a discrete sample will be collected instead of a composite sample.

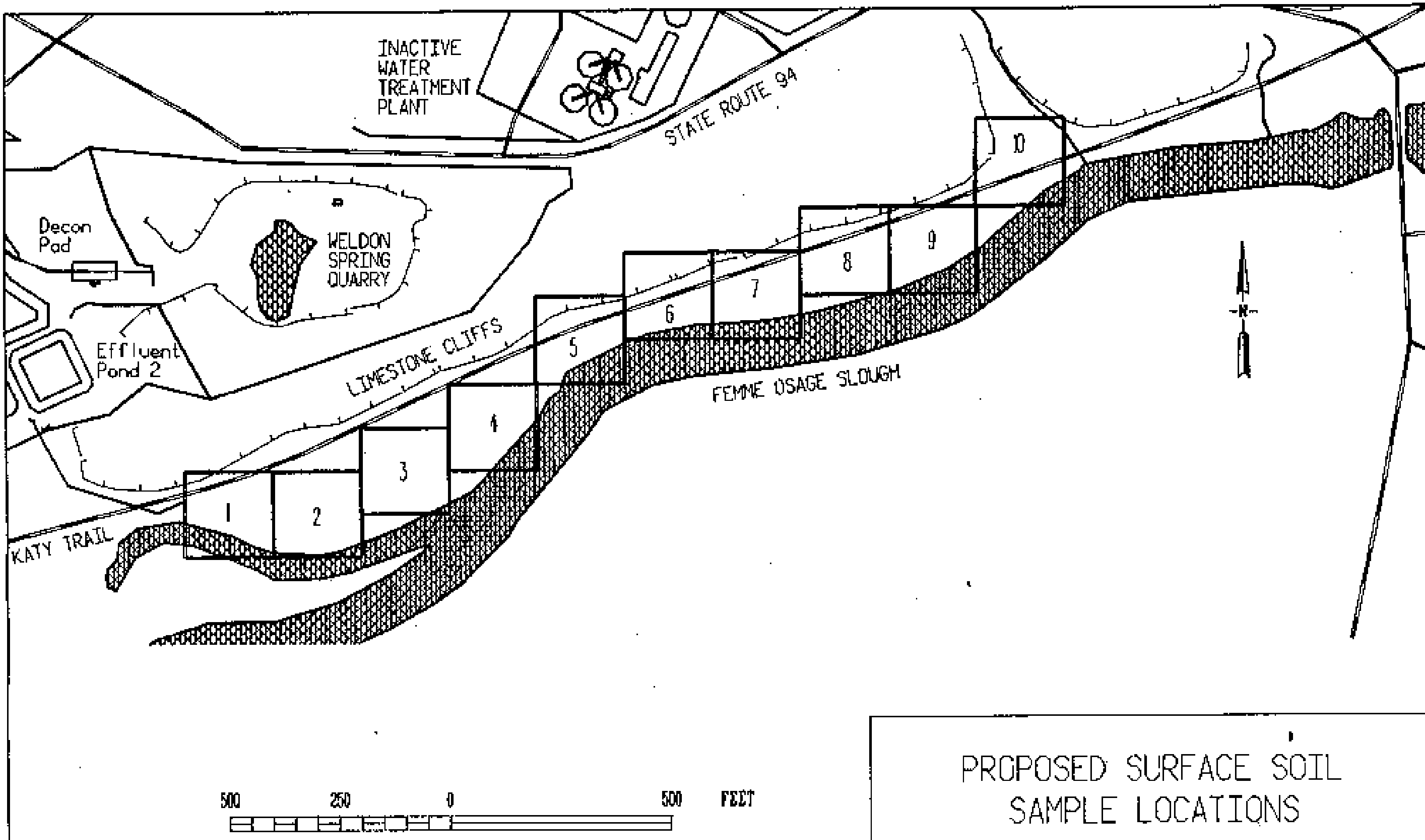
Continuous field monitoring for radiological contamination will be performed during all drilling and sampling activities. A lithologic log for each borehole will be prepared by a qualified geologist or trained technical person.

Because the objective of Phase IA is to perform identification and verification sampling as well as to obtain an estimate of mean contaminant concentrations, analyses will include TCL, TCL metals, nitroaromatic compounds, radiological constituents (except radon), total uranium, sulfate, geochemical parameters (except Br, alkalinity, TDS, TSS), and pH. Soil moisture measurements will be taken, and saturated conditions will be noted. All samples will be analyzed for total uranium. Additional parameters from the previous analysis list will be selected prior to sampling each interval. Appropriate physical analyses (see Section 7.3.1) will be taken at prescribed intervals.

8.9.2 Surface Soils

North of the Femme Osage Slough, surface soil samples will be collected to examine results from previous studies (e.g., ORAU 1986), to estimate mean contaminant concentrations, and to assist in refining the PCOC list. Figure 8-13 illustrates these ten 61-m by 61-m (200-ft x 200-ft) grid locations. Some areas are not 61-m by 61-m (200-ft by 200-ft) because of the location of the quarry rim; no soil samples will be taken on the quarry rim. In addition, there are some areas missed by the grid because of the property's shape. These grids may need to be refined based on field inspection, especially if different soil types are encountered and if the soil has been reworked.

Surface samples (approximate depth = 0.15 m [0.5 ft]) will be composited from nine locations within each grid and analyzed for TCL metals, nitroaromatic compounds, radiological constituents (except Pb-210 and radon), sulfate, pH, and percent moisture. A grain size distribution will also be performed.



PROPOSED SURFACE SOIL SAMPLE LOCATIONS

FIG. 8-13

REPORT NO: DOE/OR/21548-382		EXHIBIT NO: A/QY/038/0493
ORIGINATOR: SLH	DRAWN BY: WSSRAP GIS	DATE: 03/93

8.9.3 Background Subsurface Soil Sampling

Previous soil samples collected specifically for alluvial sediments have been limited and are not necessarily site specific. Therefore, background subsurface soil samples will be collected as part of Phase IA. Four background subsurface soil samples will be collected as part of Phase IA. In addition, if soil types are not comparable, further background sampling may be necessary.

Samples will be collected from surface to bedrock in the same manner as other proposed subsurface soil samples and analyzed for the same constituents.

8.9.4 Sample Collection

Soil samples will be collected by trained personnel according to ES&H Procedure 4.4.5. Sample collection of unconsolidated materials is discussed in Section 7.1.1. Applicable SOPs are listed in Section 10. Discrete samples analyzed for VOCs will be collected from a specific depth and will not be composited. Compositing of surface and subsurface samples will be performed by mixing equal aliquots of soil in a decontaminated stainless-steel pan using a spatula. During compositing, any detritus (e.g., leaves, twigs) will be removed. A description of each sample (e.g., an approximate grain size distribution, color, organic matter) will be made prior to and after compositing. Discrete samples will also be described. Equipment decontamination is described in Section 7.1.5.

Samples to be analyzed for volatiles will be collected at discrete intervals with minimal activities that can volatilize contaminants. No head space will be left in sample containers. Samples collected for analysis of nitroaromatic compounds will be placed in amber glass and protected from direct ultraviolet radiation (sunlight).

Sample containers for metal, nitroaromatic, sulfate, and semi-VOC analyses include separate 250-cc amber, wide-mouth bottles. For VOCs, two 40-ml vials will be used. Samples for radiological analysis will be collected in 500-cc amber, wide-mouth bottles. Sample container sizes are preliminary and subject to change depending upon the number of laboratories contracted for analyses and their specifications for required quantities.

Sample numbers will be assigned according to ES&H Procedure 4.1.1. Sample chain of custody will be maintained in accordance with ES&H Procedure 4.1.2. Immediately after collection and during shipment, samples will be kept on ice.

Field information from soil sampling will be entered in accordance with ES&H Procedure 4.4.5, *Soil/Sediment Sampling*, on the Soil/Sediment Sampling Form 4.4.5.1. Field logbooks must be completed in accordance with ES&H Procedure 1.1.4. Lithologic logs will be prepared in accordance with WSSRAP forms.

QA/QC samples have not been included in this discussion but will be collected according to the schedule presented in Section 10. The deionized water blank is not applicable, and one field blank will be collected for every 20 samples (or one per sampling event). Composition of the field blank will be determined during sampling. Field supervision by DOE authorized personnel will be used when appropriate.

8.9.5 Phase IB

Results from Phase IA, along with historical data, will be used to design sampling efforts for Phase IB. If Phase IB is necessary, a description of the sampling efforts will be discussed in the Phase IA report. Designs intended to optimize further sampling efforts will be employed where appropriate. Additional support studies, such as determination of soil K_ds for inorganic constituents, will be addressed if these studies are identified as necessary after Phase IA sampling.

9 ECOLOGICAL CHARACTERIZATION SAMPLING ACTIVITIES

Ecological characterization activities will be conducted to support an Ecological Risk Assessment at the Quarry Residuals Area. The ecological characterization will be implemented in a phased approach in conjunction with the phased approach of the overall Remedial Investigation.

Phase I ecological characterization activities will provide information to complete a preliminary characterization of the ecology of the Quarry Residuals Operable Unit (QROU), to facilitate comparison of the ecology of the QROU with background conditions, and to complete a preliminary risk determination. Data generated during ecological characterization activities will serve as a benchmark for evaluating the success of any remedial actions.

This section describes the methodologies and rationale for conducting preliminary Phase I ecological characterization activities at the QROU. These activities include vegetation surveys, herpetofauna surveys, listed-species surveys, wetland delineations, and thermal imagery. Surveys will be conducted both at the QROU and at reference areas to facilitate comparison of the ecology of the QROU with background conditions. Surveys of birds, fish, small mammals, turtles, and benthic invertebrates have previously been conducted in the Quarry Residuals Area (MKF and JEG 1992b, 1992f). Populations and community structures within these groups of organisms have been adequately characterized; therefore, additional survey activities regarding these biological groups are not identified as preliminary Phase I tasks.

Additional Phase I and/or Phase II ecological activities will be conducted as necessary to complete an Ecological Risk Assessment for the QROU. Potential additional activities are described in Subsections 9.9 and 9.10 of this plan, and include toxicity testing and tissue analyses. Such activities would be addressed in a Supplementary Ecological Characterization Sampling Plan.

9.1 Study Area Definition

Since the QROU is composed of diverse habitat types and biological communities, it has been partitioned into specific ecological study areas. Establishment of these study areas will allow Phase I ecological characterization sampling activities focus on relatively discrete biological elements. Sampling within each ecological study area will be random to the extent feasible. The following study areas have been identified for the QROU:

A-1 Little Femme Osage Creek, from the Katy Trail to its confluence with Femme Osage Creek

A-2 Femme Osage Creek, from its confluence with Little Femme Osage Creek to its confluence with the Missouri River

A-3 Femme Osage Slough

T-1 Upland habitat between the quarry perimeter fence and cliff

T-2 Bottomland forest associated with Vicinity Property No. 9

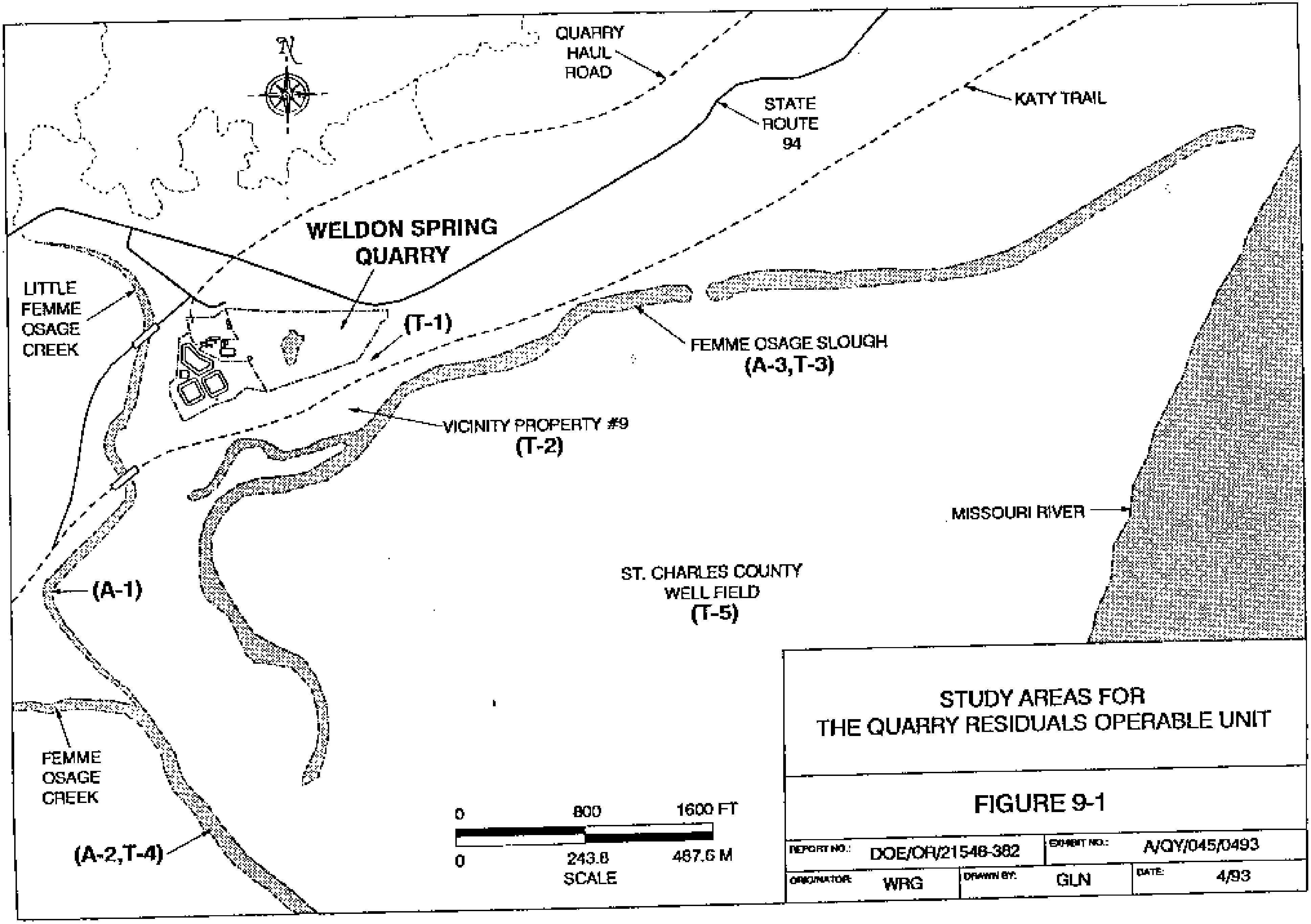
T-3 Bottomland forest/riparian habitats associated with the Femme Osage Slough

T-4 Bottomland forest/riparian habitats associated with the aforementioned segments of Little Femme Osage Creek and Femme Osage Creek

T-5 Agricultural fields in the St. Charles County well field area

The locations of these study areas are shown in Figure 9-1. Study areas associated with the aquatic system pathway are designated A-1 through A-3. Study areas associated with the terrestrial system pathway are designated T-1 through T-5. Specific survey locations at these study areas will be determined in the field and will be designed to include habitats representative of each study area. Figure 9-2 depicts the primary habitats at the QROU.

Soil, surface water, and sediment sampling and analyses for these study areas are described in Section 8. Study areas where contaminated media have previously been detected include Little Femme Osage Creek (A-1), Femme Osage Creek (A-2), Femme Osage Slough (A-3), and Vicinity Property No. 9 (T-2).



STUDY AREAS FOR
THE QUARRY RESIDUALS OPERABLE UNIT

FIGURE 9-1

REPORT NO.:	DOE/OR/21548-382	EXHIBIT NO.:	A/QY/045/0493		
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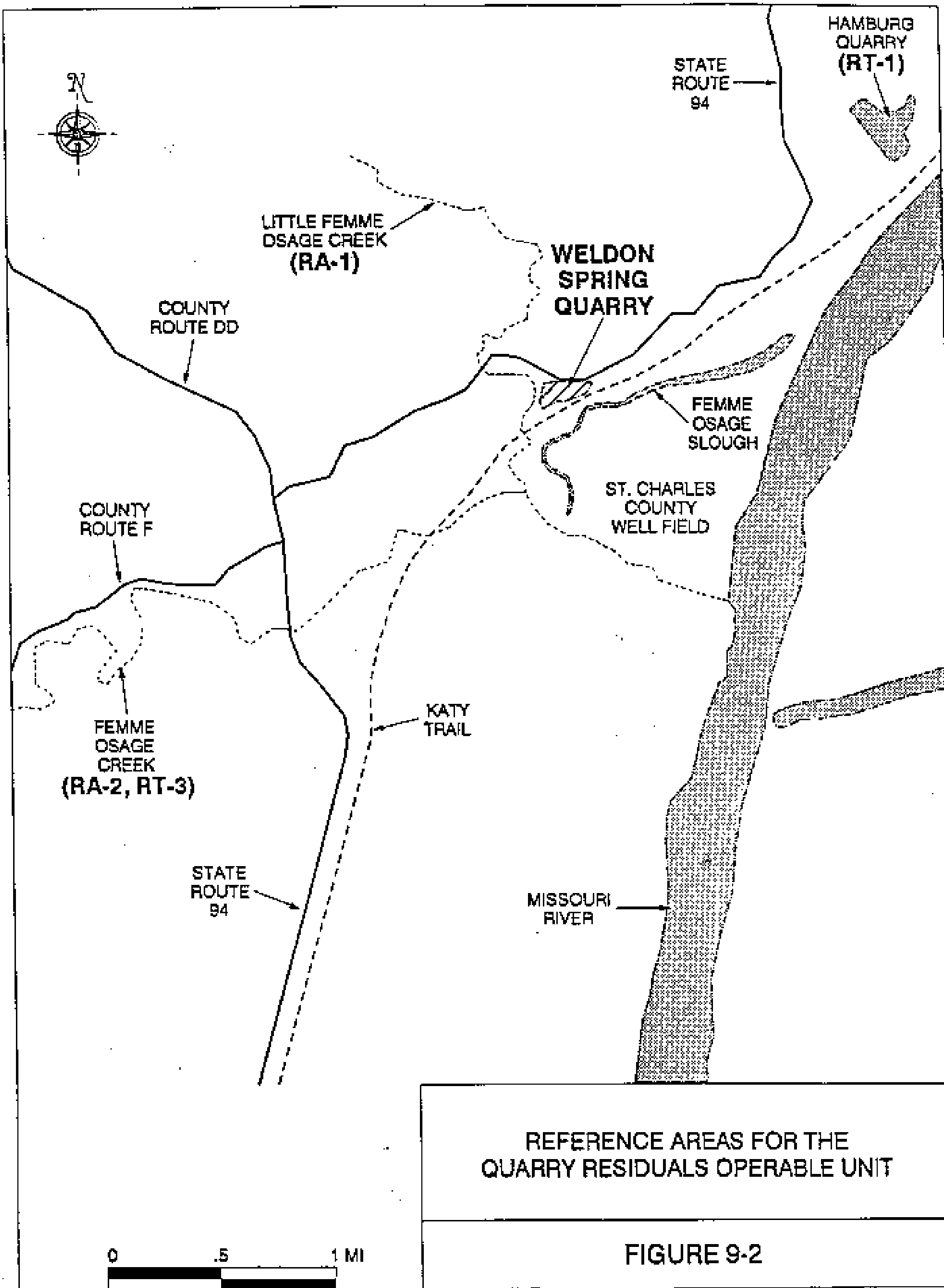


REFERENCE AREAS FOR THE
QUARRY RESIDUALS OPERABLE UNIT

FIGURE 9-2

REPORT NO.:	DOE/OR/21548-382		EXHIBIT NO.:	A/QY/046/0493	
ORIGINATOR: WRG		DRAWN BY: GLN		DATE: 4/93	

9.2 Reference Area Selection

Ecological characterization information pertaining to QROU study areas will be compared to similarly derived information pertaining to appropriate reference areas. An appropriate reference area has been selected for each study area or group of similar study areas at the QROU. The following reference areas have been identified:

RA-1 An upstream segment of Little Femme Osage Creek (reference area for A-1)

RA-2 An upstream portion of Femme Osage Creek (reference area for A-2)

RA-3 The Augusta Slough (reference area for A-3) see Figure 9-3

RT-1 An area of upland deciduous forest at the Hamburg Quarry in the Weldon Spring Wildlife Area (reference area for T-1)

RT-2 An area of bottomland forest/riparian habitats associated with the Augusta Slough (reference area for T2 and T3)

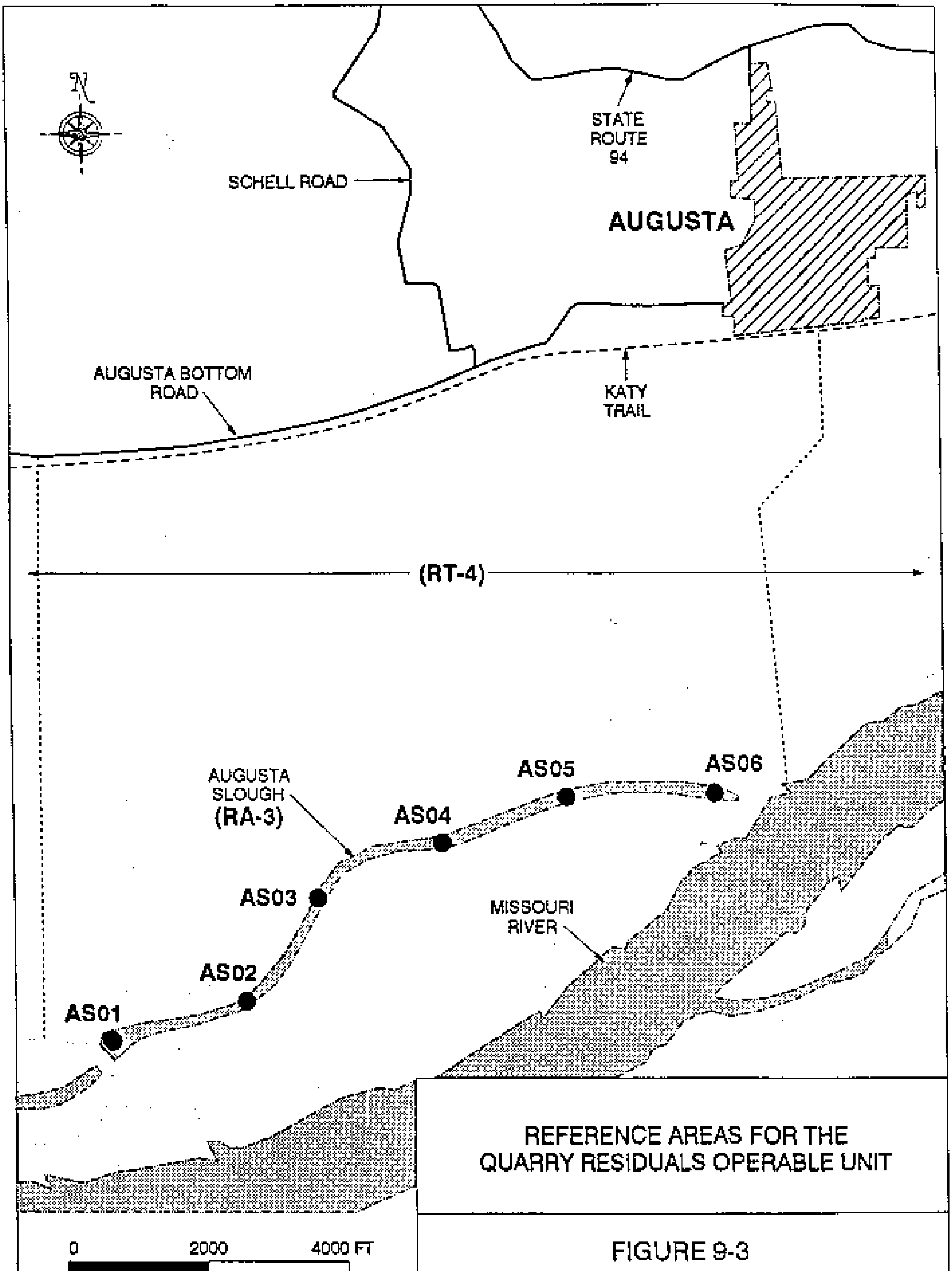
RT-3 An area of bottomland forest/riparian habitat at an upstream area of the Femme Osage Creek (reference area for T-4)

RT-4 Agricultural fields in the Missouri River floodplain near the Augusta Slough upstream of the QROU vicinity (reference area for T-5) Figure 9-3

Each reference study area was selected to have habitat characteristics similar to the respective study area(s). Selection of reference areas was based on the following general criteria:

For aquatic systems:

- Similar watershed characteristics (e.g., size and general land use)
- Similar structural attributes (e.g., width, depth, pool:riffle ratio)
- Similar hydrologic features (e.g., flow rates)
- Lack of apparent current or historical sources of contamination



REFERENCE AREAS FOR THE QUARRY RESIDUALS OPERABLE UNIT

FIGURE 9-3

REPORT NO.:	DOE/OR/21548-382	EXHIBIT NO.:	A/VP/032/0493		
ORIGINATOR:	WRG	DRAWN BY:	GLN	DATE:	4/93

For terrestrial systems:

- Similar surrounding land use patterns
- Similar vegetative structural attributes
- Similar topographic, hydrologic, and soil characteristics
- Lack of apparent current or historical sources of contamination

9.3 Overview of Previous Ecological Surveys

The following annotated list provides a brief overview of previous ecological surveys specific to the QROU area. The scope, methodologies, and results of these previous surveys appear to provide adequate characterization of the species addressed. Additional study of these species will not be conducted during Phase I ecological characterization activities. Refer to site environmental reports for results of these studies (MKF and JEG 1992g and 1993).

Avifauna. Bird surveys have been conducted in all QROU study areas and selected reference areas, as well as along the Missouri River. The scope of surveys have ranged from general avifauna surveys to focused surveys for waterfowl and owls. These surveys have been conducted in all months of the year, providing a comprehensive overview of avifauna presence and occurrence at the QROU. (Note: reference areas were not necessarily the same as those identified for the survey activities covered by this sampling plan.) Species commonly sighted within the study areas included the American goldfinch, American crow, common grackle, indigo bunting, and northern cardinal. Listed species observed include the northern harrier (*Circus cyaneus*), loggerhead shrike (*Lanius ludovicianus*), Swainson's hawk (*Buteo swainsonii*), and bald eagle (*Haliaeetus leucocephalus*).

Small Mammals. Small mammal surveys using live trap (Sherman trap) arrays have been conducted at various locations throughout the QROU area. Only mice, voles, and shrews were surveyed by this technique. Specimens were also collected for radiological analysis. The deer mouse, *Peromyscus maniculatus*, was the only species trapped within the study areas.

Fish. Fish surveys have been conducted in the aquatic study areas and in selected reference areas (again, not the same reference areas associated with this sampling plan). Fish surveys were conducted using electrofishing equipment and seines. In addition to community structure analysis, specimens of various sport fish (i.e., crappie, sunfish, bass, carp, and catfish) from the Femme Osage Slough were collected for analysis for the presence of uranium isotopes (U-234, U-235, and U-238). Species found during electrofishing in the slough include grass carp, catfish, largemouth bass, sunfish, and crappie. The most common species caught by seining in the slough included bluegill, brook silverside, white crappie, and mosquito fish. Seining results from the Little Femme Osage Creek included such species as the blackstripe topminnows, emerald shiners, and bluntnose minnows.

Turtles. Turtle surveys were conducted in Femme Osage Slough to determine whether listed species of turtles were present. Surveys were conducted using live traps and seines. The common snapper, red-eared slider, western painted turtle, false map turtle, and eastern spiney softshell were trapped and released during surveys. No listed turtles were caught or sighted during these surveys.

Benthic Invertebrates. An aquatic surveillance monitoring program is currently in place at the QROU. Benthic invertebrate and zooplankton surveys were conducted twice in 1991 and four times in 1992. Sampling stations were located in both Femme Osage Slough and Little Femme Osage Creek. These surveys were conducted using standard Surber sampler, ponar dredge sampler, and Schinder-Patalas trap methodologies. In addition, benthic invertebrates were collected for analysis for biouptake of total uranium. Benthic invertebrates species found during surveys included *Chaoborus*, *Cladopelma*, *Cryptochironomus*, and *Procladius*. Although there were no distinct differences in the benthic communities along the gradient between the north and south arms of the slough, a separate background location has been selected for the 1993 aquatic monitoring. Zooplankton results showed that the slough is predominated by rotifera. Sampling is planned to continue during 1993.

9.4 Vegetation Surveys

Vegetation surveys will be conducted to (1) characterize the plant communities and habitats present at QROU study areas and at reference study areas; (2) compare typical vegetation parameters measured at the QROU with those measured at the reference areas; (3) systematically investigate for the presence of threatened, endangered, or rare plant species; and (4) provide a preliminary evaluation of faunal food resources which may be at risk of contamination. Information regarding plant community structure, such as diversity calculated using the Shannon-Wiener index, will be used to compare the study areas to the reference study areas. Information pertaining to potential food resources will be used to evaluate food chain risks posed to biota of special concern, which include threatened, endangered, or rare (listed) faunal species, and vector species, which represent human food chain items. Evaluation of food chain risks will be based on tissue analyses of selected biota. Detailed information pertaining to habitat types will be evaluated to determine whether appropriate habitat exists for the possible presence of threatened or endangered species known to occur in the Weldon Spring vicinity or that have been observed in the QROU.

General walkover of the drilling locations may be necessary to look for threatened or endangered plant species before such operations begin. This will be determined on a case-by-case basis; e.g., locations within agricultural fields or disturbed areas need no investigation.

Study Areas. Vegetation surveys will focus on those study areas with known or suspected soil contamination or where the vegetation may otherwise be potentially exposed to contaminated surface water (e.g., riparian habitats). These study areas represent the expected extent of potential terrestrial impacts. The following study areas represent the vegetation survey study areas and are defined by the major habitat type present in each area of concern: study areas T-9 through T-4 and reference areas RT-1, RT-2, RT-3 (see Subsections 9.1 and 9.2 for habitat descriptions).

Figure 9-1 depicts the locations of these areas. While most study areas are contiguous, study area boundaries have been subjectively established for mapping and identification purposes. These boundaries are generally based on primary habitat type.

During Phase I, vegetation surveys will be conducted at each of the quarry residuals study areas (T-1 through T-4) and at the respective reference areas (RT-1 and RT-2). Standard methods of stratified random sampling and describing plant communities will be used at these study areas (Barbour et al., 1987; Warren-Hicks et al., 1989). Due to the dynamic nature of plant communities, vegetation surveys will be conducted twice during the growing season: once in the spring and again in the late summer/early fall. These periods of the growing season were selected to adequately account for any seasonal changes in plant presence and dominance. The same sampling points will be used during each survey. The surveys are designed to characterize the plant community structure, to identify potential vegetative food resources which may be utilized by biota of special concern, and to provide detailed information regarding habitat types at each study area.

The agricultural fields study area (T-5) survey will be conducted separately from the standard vegetation surveys. Characterization of the agricultural fields themselves will not be conducted, since each field is assumed to represent a monoculture of an agricultural crop. Vegetation occurring in the roadside ditches, hedgerows, field corners, and corridors which constitute the remainder of the patchwork land cover in the well field will be characterized in general terms during roadside surveys. Tissue analyses will not be conducted on crop species as part of this Phase I ecological investigation, since a monitoring program is currently in place to evaluate contaminant uptake by crop plants (MKF and JEG 1992e).

Sampling Methods. Vegetation communities will be characterized and quantified at random sample points along line transects, using a combination of quadrats and point-centered quarter sampling methods. Generally, transects will be established along the longest axis of each study area. Along each transect, stratified random sampling points will be established according to distance intervals either derived from a random-numbers table or generated by an electronic device. At each sampling point, the distance-based, point-centered quarter method will be used to collect data pertaining to trees. Trees are defined as erect, woody plants with a stem diameter at breast height (DBH) greater than or equal to 10 cm. DBH measurements will be taken with a DBH tape. In addition, a quadrat, measuring 2 m by 2 m with an area of 4 m^2, will be used to collect data pertaining to shrubs. A smaller quadrat, measuring 1 m by 1 m with an area of one square meter (1 m^2), will be used to collect data pertaining to herbaceous plants. Shrubs are defined as erect or prostrate woody plants with a stem DBH less than 10 cm. Seedlings and saplings of tree species (i.e., with DBH less than 10 cm) will be scored in the shrub category, using the 4-m^2 quadrat. Herbaceous plants are defined as all non-woody plants. The following text describes the field procedures for conducting the vegetation surveys.

Vegetation survey transects will be established to characterize the vegetation most representative of each study area. Transects will not cross study area boundaries. The location of each transect will be selected in the field on a subjective basis, with the objective that each transect pass through representative portions of the study area. Transects associated with study area T-1 will be established so that each transect radiates perpendicularly to the quarry perimeter fence. The distance between transects will be 10 m. Transects associated with RT-1 will be designed to be of similar length and number. It is expected that four to six transects will be required to adequately characterize each study area.

Approximately four line transects will be established in study area T-2. Each transect in study area T-2 will run generally in the direction of the longest axis of the study area. It is expected that each transect will be 170 m to 210 m in length. A similar number of line transects (of similar length) will be established in a bottomland forest portion of study area RT-2.

In study areas T-3 and T-4, which are long and curvilinear in shape, the transects will run parallel to the surface water body and will be established on both sides of the water body. One transect will be established for every 5 m of riparian vegetation away from the respective surface water body. If discrete stands of obligate wetland plants are encountered during the surveys, separate vegetation surveys will be conducted for these areas. A similar number of line transects (of similar length) will be established in riparian vegetation portions of study area RT-2.

The location of each line transect (beginning and end) and the location of each sampling point along the transect will be marked with coded red flags. Once the beginning of a transect has been established and the direction of the transect has been selected, stratified random sampling points will be located along the length of the transect, using distances either derived from a random-numbers table or generated by an electronic device. Beginning at one end of the transect, the investigator will generate a random number, which will translate to a distance in meters. Random numbers will range from 0 to 9. "Zero" will be interpreted as "10." The first random sampling point will be measured from the beginning point of the transect. The second random sampling point will be measured from a discrete point on the line transect 10 m from the beginning. The third random sampling point will be measured from a discrete point on the line transect 20 m from the beginning, and so on. This stratified design will allow dispersion of sampling points. Sampling points along the transect will never be more than 19 m apart.

At each sampling point along the transect, the area around the point will be divided into four 90° quarters, as defined by the cardinal points of a compass. Within each quarter, the tree closest to the sampling point will be located, distance measured, and identified to species. The basal area of the tree (i.e., the trunk cross-sectional area derived from DBH measurement) will be determined (to the nearest 0.5 cm) from the circumference of the trunk at breast height (in centimeters) and recorded. The distance from the sampling point to the tree will be measured (to the nearest 0.1 m) and recorded.

The shrub and herbaceous vegetation along the transect will then be characterized. At each sampling point, the investigator will determine which two opposing cardinal point lines are most perpendicular to the transect. The 1-m^2 quadrat will then be placed 1 m from the sampling point on each of these opposing lines, and the larger 4-m^2 quadrat will be placed along the farthest edge of the small quadrat. Within each large quadrat plot, the number of stems of each shrub species will be recorded. Shrub species records will also be subdivided into two classes based on height: those individuals less than 1 m tall, and those individuals greater than 1 m tall. An estimation of coverage will be made and recorded. The cover value for each shrub species present in the large quadrat plot will be estimated according to cover classes listed in Table 9-1. Herbaceous vegetation will then be characterized within the small quadrat, based on estimations of cover. The cover value for each herbaceous species present in the small quadrat plot will be estimated according to cover classes listed in Table 9-1, and the values will be recorded.

TABLE 9-1 Modified Braun-Blanquet Cover Class Ranges

Class Contribution to Total Cover

Cover Class	Range, in %	Mean, in %
5	75 to 100	87.5
4	50 to <75	62.5
3	25 to <50	37.5
2	5 to <25	15.0
1	1 to <5	3.0
+	<1	0.5
r	Observed, but so rare as to not contribute	significantly

Warren-Hicks et al., 1989

<u>Special Surveys</u>. The aforementioned survey methodologies are useful in characterizing the vegetative community within a specific area; however, rarely occurring species tend to be excluded using these methodologies. Special survey procedures to identify listed species will be implemented in addition to the standard vegetation surveys. Species to be included in these special surveys were derived from the list of Federal- and State-listed species reported from

St. Charles County (Table 3-3). Species with a State watch list status only will not be included in these special surveys, since such a status does not imply that those species are imperiled. Using habitat information generated during the standard vegetation surveys, probable locations of occurrence will be identified based on the preferred habitat of each listed species. These special surveys will use the same transects as before, with careful visual inspection for those listed individuals not recorded during the standard vegetation surveys. The width of the visual search path will be approximately 5 m on either side of the transect.

TABLE 9-2 Listed Plant Species Identified for Special Surveys

Common Name	Scientific Name	Federal Status[a]	State Status[b]
Arrow arum	*Peltandra virginica*	-	R
Rose turtlehead	*Chelone obliqua* var. *speciosa*	3C	E
Star duckweed	*Lemna trisulca*	-	R
Decurrent false aster	*Boltonia decurrens*	T	E

[a] T - Threatened; 3C - Former federal candidate species.
[b] R - Rare; E - Endangered.

Routine wetland determinations will be performed separately from the standard vegetation survey effort, since vegetation characterization methodologies required for wetland determination procedures (e.g., as established by Environmental Laboratory 1987) differ significantly from methodologies used in the standard vegetation surveys. Subsection 9.7 describes formal wetland determination procedures to be implemented at the QROU.

9.5 Herpetofauna Surveys

The primary objective for conducting herpetofauna surveys is to determine whether Federal- or State-listed reptile or amphibian species occur in areas of known or possible soil, surface water, or sediment contamination. Species richness and relative abundance of herpetofauna occurring in the study areas will be compared with the same parameters associated with the reference areas. Herpetofauna surveys will be conducted in all study and reference areas except the agricultural fields. The agricultural fields will not be surveyed since they are not expected to provide preferred herpetofauna habitat.

The natural history of reptiles and amphibians precludes the use of any single survey method. Sampling and survey methods must take into consideration such elements as sensitivity to weather conditions, secretive behavior, seasonal activity patterns, diurnal/nocturnal activity patterns, multiple life stages, and diverse habitats. Survey methods to be used for the herpetofauna survey will include transect surveys, terrestrial trap arrays, artificial shelters, nighttime auditory surveys, and seining. Surveying will be conducted in two seasons: once in March or April, and once in September or October. Each seasonal survey period will last four to six weeks. Exact timing of herpetofauna survey activities will be very weather-dependent, since herpetofauna are very sensitive to climatic extremes.

Transect Surveys. Transect surveys will be conducted to identify lowland or semi-aquatic species of reptiles and amphibians. Twice during each survey period, transects will be surveyed within the riparian vegetation and shoreline areas of Femme Osage Slough (T-3), Femme Osage Creek and Little Femme Osage Creek (T-4), and the riparian portions of the reference study area (RT-3). Within each study area, transects will be established along the bank of the surface water body at random intervals of not less than 50 m and not more than 100 m. Distance intervals will be derived from a random-numbers table. Numbers derived from the random-numbers table will be multiplied by 5 and added to 50. At each interval, a 5-m-wide belt transect will be surveyed, beginning (in stream) 1 m from the bank and extending through the riparian belt perpendicular to the water body. The location of the centerline of each transect will be marked at the outside edge of the riparian belt with a coded red flag. Surveying will consist of visual observation of the ground surface, including areas beneath rocks or debris. The in-water portion of each transect will be visually inspected for egg masses. Other potential herpetofauna habitat within the belt transect (e.g., inside dead logs or within piled debris) will also be inspected, as permissible. All rocks and debris will be returned to their original locations and positions. Species and numbers of herpetofauna observed along each transect will be recorded. Data recorded will include species observed, location, habitat type, weather conditions, temperature, and time of day. Additional signs of herpetofauna (such as tracks, nests, egg masses, etc.) will also be recorded.

Trap Arrays. Terrestrial trap arrays will be used to survey mobile herpetofauna species. Two terrestrial trap arrays will be placed in the area between the quarry fence and the Katy Trail (T-1) and two at Vicinity Property No. 9 (T-2). The same number of arrays will be placed at the same intervals in the reference areas (RT-1 and the bottomland forest portion of RT-2). Each array will consist of three 7.5-m lengths of drift fence in a "Y" configuration. A pitfall trap will be placed at the juncture of the three "arms," and funnel traps will be placed at the midpoint of each arm on either side of the fence and at the terminus of each arm (for a total of nine funnel traps). Shade covers will be placed over the pitfall trap and over each of the funnel traps, and moist sponges will be placed in the traps. Array traps will be opened for three days every two weeks during each survey period. Array traps will be run daily when they are open. Species and number of captured herpetofauna will be recorded for each array. All individuals will be released on the opposite side of the fence from where they were caught following data recording. When the arrays are not in use, pits will be covered and funnel traps will be hung in nearby trees. Nonherpetofauna species will also be recorded. Dead individuals found in traps will also be identified to species (if possible) and recorded, and disposed of at least 50 m from an array. Data recorded will include species captured, location, habitat type, weather conditions, temperature, and time of day.

Artificial Shelters. Artificial shelters, constructed of corrugated roofing sheet metal, will be used to survey secretive species as well as resting individuals of more mobile species (Fitch 1992). Each artificial shelter measures 0.6 m by 1.2 m and will be used in conjunction with the terrestrial trap arrays. Depending on the final layout of the trap arrays, approximately 20 artificial shelters will be placed around and between arrays within a particular study area. Artificial shelters will be placed in such a way as to fill in spatial gaps among and around the arrays. The number of artificial shelters placed at reference study areas will match the number placed at the respective study area. Artificial shelters will be checked at the same time and on the same frequency as the trap arrays. Data recorded will include species observed, location, habitat type, weather conditions, temperature, and time of day.

Auditory Surveys. Nighttime auditory surveys will be conducted to identify breeding amphibians present at the QROU study and reference areas. A 15-min observation period will be conducted at each study and reference location during appropriate weather conditions such as light rain and warm temperatures. Data recorded will include species observed, observation type (audial or visual), location, habitat type, weather conditions, temperature, and time of night.

9.6 Selected Listed Faunal Species Surveys

Of the diverse group of organisms listed in Table 3-3, several have been selected for focussed survey activities. These species have been selected for additional surveying since individuals of these species have been observed within the QROU, and they are not addressed in any other Phase I survey activity. Two different surveys will be conducted: bald eagle surveys along the Missouri River and surveys for three other listed avian species within the St. Charles County well field.

9.6.1 Bald Eagle Surveys

Special surveys will be conducted to establish whether bald eagles (*Haliaeetus leucocephalus*) actively use specific areas within the QROU for feeding, roosting, or nesting. Bald eagles have been observed using Howell Island for winter roosting and using the Missouri River for feeding. Bald eagle surveys will focus on the following aspects:

- Presence of resident individuals (not expected)
- Occurrence of migrating individuals (expected)
- Winter roosting activities (expected)
- Nesting activities (not expected)
- Winter feeding grounds (unknown)

Bald eagle surveys will consist of periodic observation conducted from a central viewing location such as the public access boat ramp on the Missouri River, located within the St. Charles County well field. The frequency of observation periods will vary seasonally. Observations will be conducted three times a week during December, January, and February. Because bald eagles are known only to winter in the area, after February, casual observations will be made while conducting other surveys within the QROU area. Each observation period will be approximately 15 min in length, will be conducted at approximately sunrise, and will be performed by using field glasses or a spotting scope to scan the sky, Missouri River, and tree lines for individuals.

9.6.2 Special Surveys for the Loggerhead Shrike, Northern Harrier, and Swainson's Hawk

Special surveys will be conducted for the loggerhead shrike, northern harrier, and Swainson's hawk to establish whether these species actively use specific areas within the QROU for feeding, roosting, and/or nesting. All these species have been observed in the agricultural fields located in the St. Charles County well field (T-5). In general, observation will take place three times a week from various locations throughout the well field in the morning hours following sunrise. Each observation period will be approximately 15 min in length and will be performed by using field glasses or a spotting scope to scan the sky, trees, fence posts, and power lines for individuals.

The records will be maintained for each individual observed, including such information as the date, the time of day, whether the individual is adult or juvenile, the activity observed, and the location where the observed activity took place.

Further specifics for each species are presented below.

9.6.2.1 Loggerhead Shrike Surveys. Loggerhead shrike (*Lanius ludovicianus*) surveys will focus on the following aspects:

- Presence of resident individuals (expected)
- Occurrence of migrating individuals (expected)
- Feeding activities (expected)
- Nesting activities (expected)

Loggerhead shrike survey activities will focus in the well field area, since preferred habitat is open country with lookout posts, wires, and scattered trees. Because loggerhead shrike often impale their prey upon barbed wire or plant spines/thorns, these will also be searched for and noted during observations. Loggerhead shrike surveys will be conducted both on a formal basis and while driving and working in the QROU area. The frequency of observation periods will vary seasonally. During April, May, and June (breeding season), formal observations will be conducted three times a week. During this season, observations will focus on signs of breeding, such as courtship behavior and nest-building activities. At other times of the year, observations will be made on a casual basis.

9.6.2.2 Northern Harrier Surveys. Northern harrier (*Circus cyaneus*) surveys will focus on the following aspects:

- Presence of resident individuals (expected)
- Occurrence of migrating individuals (expected)
- Feeding activities (expected)
- Nesting activities (expected)

Northern harrier surveys will consist of formal observations and casual observations conducted while driving and working in the QROU area. Survey activities will focus on the well field area, since preferred habitat consists of fields and marshes. The frequency of observation periods will not vary seasonally since northern harriers are resident individuals.

9.6.2.3 Swainson's Hawk Surveys. Surveys for Swainson's hawks (*Buteo swainsonii*) will focus on the following aspects:

- Presence of resident individuals (not expected)
- Occurrence of migrating individuals (expected)
- Feeding activities (expected)
- Nesting activities (not expected)

Swainson's hawk surveys will consist of casual observations conducted while driving and working in the QROU area. Survey activities will not focus on any particular portion of the QROU, since the preferred habitat of Swainson's hawks is diverse and they are a migratory species.

9.7 Wetland Delineations

Wetland delineations will be conducted as a specific task separate from the vegetation surveys presented in Subsection 9.4. Areas along Femme Osage Creek, Little Femme Osage Creek, and Femme Osage Slough are identified on the U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) map (U.S. Fish and Wildlife Service 1989) as wetlands. Wetland determination and delineation will be continued using the Corps of Engineers Wetlands Delineation Manual (Environmental Laboratory 1987). Sampling methods may include routine and qualitative procedures. Surveys will be conducted in May and August so that observations can be made during both wet and dry periods and will include review of vegetation hydrology and soils. The wetland status of plant species will be determined using the wetland species list for the State of Missouri (Reed 1986).

9.8 Thermal Imagery

Thermal imagery will be used as an aid in classifying and delineating habitat types and in detecting areas of stressed vegetation (both upland and wetland/bottomland). Locations T-1 through T-4 will be included in this study; T-5, being an agricultural field is not included. Data (such as soil, pH, texture, and contaminant concentration) from the characterization study combined with information from thermal imagery will show whether stressed vegetation is due to contaminants.

9.9 Tissue Analyses

Additional ecological characterization activities may be deemed necessary or appropriate following a thorough review of existing ecological information; existing analytical data; information obtained during the preliminary Phase I ecological characterization activities; and analytical data for soil, surface water, and sediment samples collected concurrently with Phase I ecological characterization activities. Potential additional ecological characterization studies of the QROU may include the analysis of biological tissue collected from plants and animals which represent food resources for humans, threatened or endangered species, and/or important food-chain species. Tissue analyses for the presence of radionuclides have previously been conducted on a wide variety of biological tissue (i.e., fish, benthic invertebrates, and small mammals) collected from the QROU and from reference areas.

The methodologies and results of previous tissue analyses will be evaluated for completeness in satisfying the objectives of (1) characterizing potential exposures of humans and threatened or endangered species to contaminant concentrations in food resources, and (2) facilitating comparison of the contaminant concentrations in resources at the QROU with background conditions associated with the reference areas.

The aspects of these studies which will be reviewed include:

- Completeness in addressing all appropriate study areas

- Completeness in addressing seasonal characteristics
- Appropriateness of sampled biota
- Appropriateness of sampling methods
- Appropriateness of reference area
- Adequacy of number of samples
- Adequacy of analytes evaluated

Additional tissue analyses may require complete sampling and analysis efforts, or supplementary sampling and analysis efforts. Supplementary sampling and analysis may employ additional sampling methods, or address additional populations, without duplicating previous efforts. The results of the surveys presented in this sampling plan will also be evaluated to determine whether additional sampling is warranted (e.g., if important food resources of listed species are observed, or if additional human food resources are documented). If the need for additional tissue sampling and analysis is identified, an appropriate sampling and analysis plan will be prepared and submitted.

9.10 Toxicity Testing

Another potential additional ecological characterization activity is toxicity testing. Because information on toxicity of radionuclides to biota is scarce, and because the toxicity of a mixture of contaminants cannot be predicted based solely on the toxic effects of the component contaminants, preliminary toxicity screening may be determined to be appropriate to evaluate whether toxic effects on biota may be occurring. Tests chosen will be conservative and will evaluate sensitive measures of toxicity as indicators of ecological risk. Potential toxicity testing may include *Daphnia* 48-hour LC50 testing, fathead minnow (*Pimephales promelas*) 96-hour LC50 testing, root elongation testing, and earthworm toxicity testing. Acute toxicity tests using *Daphnia* or the fathead minnow are standard tests commonly used to describe the toxicity of a compound or a mixture of compounds in aquatic systems. Root elongation rate is a sensitive measure of phytotoxic effects of contaminants in soil. Earthworm toxicity testing employs the species *Eisenia foetida* in tests with soil extracts. The endpoint of earthworm toxicity testing is an LC50, with worms classified as dead when they do not respond to a gentle mechanical stimulus to the anterior end. If the need for toxicity testing is identified, an appropriate sampling and analysis plan will be prepared and submitted.

9.11 Data Reporting

As indicated in Section 1.1, the primary objectives of these Phase I ecological characterization activities are to complete preliminary characterization of the ecology of the QROU (including wetland delineations and listed species usage), to compare habitat characteristics of the QROU study areas with habitat characteristics of selected reference areas, and to analyze biological tissue of human or listed-species food resources.

Vegetation Surveys. Data analysis and reporting with respect to vegetation surveys will emphasize population and community descriptors, focussing on comparison of the QROU study areas with appropriate reference areas.

Density of trees will be expressed as the total number of individuals per unit area (e.g., hectare), and will be calculated:

$$D = \frac{10,000}{d^2} \qquad \text{Equation 1}$$

where: D = density for all tree species per hectare, and
d = average distance in meters. (Barbour et al. 1987)
(10,000 represents a conversion factor from square meters [m^2] to hectares.)

Relative density of each tree species will be calculated:

$$D_i = \left(\frac{n_i}{n}\right) D \qquad \text{Equation 2}$$

where: D_i = density for tree species i per hectare,
n_i = total number of individuals counted for species i,
n = total number of individuals counted, and
D = density for all tree species per hectare. (Brower and Zar 1984)

The total **basal area** of a tree species will be used as surrogate value for determination of **cover or dominance**. The basal area of a tree will be calculated from the circumference of the tree at breast height:

$$BA = \pi r^2 \qquad \text{Equation 3}$$

where: BA = the cross-sectional area of the trunk in square centimeters (cm^2), and
r = one-half the diameter at breast height in centimeters. (Brower and Zar 1984)

Cover or dominance of a given tree species (species i) will be calculated from the sum of basal areas of all individuals of species i:

$$C_i = \frac{\left(\frac{\Sigma i_{1..n}}{N_i}\right) D_i}{10{,}000} \qquad \text{Equation 4}$$

where: C_i = coverage by tree species i in square meters (m^2) per hectare,
N_i = total number of individuals counted for species i,
D_i = density for species i per hectare, and
$\Sigma i_{1..n}$ = the sum of all basal areas of species i. (Brower and Zar 1984)
(10,000 is a conversion factor to convert cm^2 to m^2)

The **density** of shrub species will be expressed as the number of individuals per unit area (i.e., 1 m^2), and will be calculated:

$$D_i = \frac{n_i}{A} \qquad \text{Equation 5}$$

where: D_i = density of shrub species i in m^2,
n_i = total number of individuals counted for species i, and
A = total area sampled (1 m^2). (Brower and Zar 1984)

Frequency is the chance of finding a given shrub or herbaceous species (species i) within a sample (quadrat), and will be calculated:

$$f_i = \left(\frac{j_i}{k}\right)100 \qquad \text{Equation 6}$$

where: f_i = frequency of species i in percent,
j_i = number of quadrats in which species i occurs, and
k = total number of quadrats sampled. (Brower and Zar 1984)

Estimates of **cover** or **dominance** for shrub and herbaceous plants will be derived for each species occurring in each quadrat according to cover classes presented in Table 9-1.

Each of the aforementioned ecological parameters will be used to compare ecological characteristics of the QROU study areas with the appropriate reference areas. Nonparametric methods, such as the Mann-Whitney test, will be used to test for differences between each study area and the appropriate reference areas for each parameter measured.

Herpetofauna Surveys. Data analysis and reporting with respect to herpetofauna surveys will emphasize population and community descriptors, with limited comparison of the QROU study areas with appropriate reference areas. Due to the nature of the herpetofauna surveys and the community parameters measured, statistical comparisons will not be conducted between the study areas and the reference areas. Aside from the confounding factors previously identified in Subsection 9.5, migration of herpetofauna to and from hibernacula may skew the results of these surveys. Therefore, simple numerical comparisons between study areas and reference areas will be performed.

The total number of herpetofauna species captured or observed in each study area (and appropriate reference areas) will provide an estimate of species richness for each study area.

The total number of individuals of each herpetofauna species captured or observed in each study area (and appropriate reference area) will be averaged to provide an estimate of relative abundance. Similar data analyses will be performed on groups of herpetofauna species including snakes, lizards, salamanders, frogs/toads, and turtles (see Table 9-3).

TABLE 9-3 Phase I Ecological Characterization Parameters

Activity	Biological Group	Parameter	Unit / Correlation
Vegetation Survey	Trees	Density	Number of individuals per hectare
		Relative density	Number of individuals per species per hectare
		Basal area	Surrogate value for dominance per species
		Cover/dominance	Number of individuals per unit area
	Shrubs	Density	Number of individuals per species per quadrat
		Frequency	Fraction of quadrats in which species i was observed
		Cover	Surrogate value for dominance per species
	Herbaceous plants	Frequency	Fraction of quadrats in which species i was observed
		Cover	Estimator of dominance per species
Herpetofauna Surveys	All	Species richness	Total number of species observed per study area
		Relative abundance	Proportion of total represented by species i

Listed-Species Surveys. Data generated during the listed-species surveys will be presented as descriptions of usage patterns, or presence or occurrence of those species at or in the vicinity of the QROU. This information will be used in making decisions regarding additional surveys or additional sampling of food resources for tissue analyses.

Thermal Imagery. Information generated during thermal imagery will be analyzed in conjunction with vegetation survey data and the associated derivative indices. Analytical data for soil, surface water, and sediment samples will also be used in the evaluation of thermal imagery results. Soil characteristic data (e.g., texture and pH) will similarly be considered. A map depicting areas of detectable vegetation stress potentially related to site-specific contamination will be produced.

Wetland Delineation. Data generated during the wetland delineation will be presented as descriptions and spatial delineations of wetland habitats at the QROU. A semi-quantitative description of the wetland community structure will be generated from vegetation transects conducted during the wetland delineation, and a wetland map depicting wetland boundaries will be produced.

10 QUALITY ASSURANCE

MK-Ferguson, the Project Management Contractor (PMC) at the Weldon Spring Site Remedial Action Project (WSSRAP), has developed the *Project Management Contractor Quality Assurance Program* (QAP) in accordance with U.S. Department of Energy (DOE) Order 5700.6C. As outlined in this DOE Order, the PMC QAP addresses sections of the American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance Program, NQA-1 1989 and the EPA Quality Assurance Management Staff Quality Assurance Project Plan, QAMS-005/80. The PMC QAP applies a graded approach to ensure that activities performed at the WSSRAP are of documented quality. The QAP details the 10-point criteria described in DOE Order 5700.6C to ensure that site-wide activities are performed in a quality manner. The PMC QAP has been approved by the WSSRAP U.S. Department of Energy (DOE) Project Office.

The PMC QAP is supported by Site Quality Procedures (SQPs) which direct the evaluation of quality-affecting activities by implementing independent assessments and processes that identify nonconforming conditions and ensure corrective actions.

The PMC has developed the *Environmental Quality Assurance Project Plan* (EQAPjP) to ensure that all environmental activities conducted at the WSSRAP will be performed in accordance with EPA QAMS-005/80. The EQAPjP addresses the 16-point criteria outlined in QAMS-005/80, as applicable, with support from the Standard Operating Procedures (SOPs) outlined in Table 10-1.

10.1 Standard Operating Procedures

SOPs have been developed for activities associated with environmental characterization at the Weldon Spring site. Refer to Table 10-1 for procedures applicable to this proposed sampling effort. These procedures have been developed from U.S. Environmental Protection Agency (EPA) and DOE guidance and from standard industry practices and are specific to the Weldon Spring site. Procedures at the Weldon Spring site are prepared, reviewed, and approved by cognizant department managers, the Quality Assurance Manager, and project management. Controlled copies of procedures are maintained in accordance with the document control requirements of ASME NQA-1. Procedures are reviewed at least annually and revised as appropriate.

TABLE 10-1 Procedures Applicable to Environmental Characterization Activities

Procedure Number	Procedure Title
CM&O-15	Task Specific Safety Assessments
CM&O-52	Alkalinity Analysis
CM&O-56	Total Suspended Solids Analysis
ES&H 1.1.4	Logbook Procedure
ES&H 2.5.1	Radiological Soil Sampling
ES&H 2.5.5	Sample Preparation Procedure for Radiological Soil Samples
ES&H 4.1.1	Numbering System for Environmental Samples and Sampling Locations
ES&H 4.1.2	Chain of Custody
ES&H 4.1.3	Sampling Equipment Decontamination
ES&H 4.1.4	Quality Control Samples for Aqueous and Solid Matrices: Definitions, Identification Codes, and Collection Procedures
ES&H 4.3.1	Surface Water Sampling
ES&H 4.3.2	Single Well Hydxraulic Conductivity Testing
ES&H 4.3.3	Standing Surface Water Level Measurement
ES&H 4.4.1	Groundwater Sampling
ES&H 4.4.2	Groundwater Level Monitoring and Well Integrity Inspections
ES&H 4.4.4	Subsurface Monitoring Device Plugging and Abandonment Procedure
ES&H 4.4.5	Soil/Sediment Sampling
ES&H 4.4.6	Vegetation Surveys
ES&H 4.5.1	pH and Temperature Measurement in Water
ES&H 4.5.2	Specific Conductance Measurement in Water
ES&H 4.5.6	Measurement of Dissolved Oxygen in Water
ES&H 4.5.7	Measurement of Settleable Solids
ES&H 4.5.8	Water Sample Filtering
ES&H 4.6.1	Environmental Thermoluminescent Dosimeter Deployment and Handling
ES&H 4.6.2	Radon Concentration Measurement in Ambient Air
ES&H 4.6.4	Constant Flow Air Low Volume Sampler Operation and Air Sample Filter Handling
ES&H 4.6.6	Constant Flow High Volume Air Sampler Operation and Air Sample Filter Handling
ES&H 4.9.1	Rain Gauge Manual Operation

TABLE 10-1 Procedures Applicable to Environmental Characterization Activities (Continued)

Procedure Number	Procedure Title
ES&H 4.9.1	Environmental Monitoring Data Verification
ES&H 4.9.2	Environmental Monitoring Data Validation
ES&H 4.9.3	Surface Water and Groundwater Data Review Procedure
ES&H 5.1.8	Turbidity Analysis
RC-17	Off-site Transportation of Hazardous Materials
RC-19	Hazardous Material/Sample Transportation Activity (HMSTA) Operations
RC-22	Sample Disposal
RC-30	Monitoring Well Waste Management

All sample identification, collection, and documentation will be performed in accordance with Environmental Safety and Health (ES&H) Department procedures. All documentation will be written on field sheets and/or kept in a logbook according to procedures. Completed field sheets and logbooks will be transmitted to the Project Quality Department and retained as quality assurance (QA) records upon completion of the field work.

10.2 Quality Control Samples

Quality control samples will be collected to ensure consistent and accurate performance of sample collection and laboratory analysis. See Table 10-2 for a summary of the various quality control samples that will be collected to support characterization.

TABLE 10-2 Field Quality Control Sample Summary

Quality Control Sample Type	Frequency	Purpose
Matrix Spike/Matrix Spike Duplicate or Matrix Duplicate	*1 per 20 or 1 per 14 days	Assess matrix and possible intralaboratory variability
Blind Duplicate/Secondary Duplicate	1 per 20	Assess matrix and interlaboratory variability
Replicate	1 per 20	Assess matrix and intralaboratory variability
Equipment Blank (non-dedicated equipment only)	1 per 20	Assess effectiveness of decontamination
Deionized Water Blank **	1 per month	Assess quality of deionized water
Trip Blank	1 per day when analyzing for VOAs	Assess potential cross-contamination during shipping
Field Blank**	1 per month	Assess impact of ambient conditions on samples

* Whichever is of higher frequency.
** Collected together on the same day.
VOA = volatile organic analysis

10.3 Quality Assurance Records

Records generated as a result of this investigation will be maintained as QA records. Field sampling forms, analytical data, equipment calibration records, and verification and validation documentation records are all considered QA records and are maintained by the Project Quality Department in accordance with the requirements of NQA-1, 1989. This provides both security and protection to critical records.

10.4 Independent Assessments (Audits)

Independent assessments and surveillances of WSSRAP environmental activities are routinely conducted by the Project Quality Department. These activities include analytical services, data management, sample management, and programmatic procedures. Nonconforming conditions identified in independent assessments and surveillances will be tracked by the Site Wide Audit Tracking System (SWATS) until corrective actions have been implemented.

Laboratories performing analyses for the Weldon Spring site are audited routinely. These audits are directed by a lead auditor from the Project Quality Department, with support provided by a select team of site personnel who have knowledge of analytical methods and procedures. These audits focus on compliance with the project-specific *Quality Assurance Project Plan* (QAPjP) prepared by the laboratories prior to performing sample analysis and with laboratory-specific procedures and policies. An audit report is generated and corrective actions tracked by the SWATS.

Proposed Laboratories

Barringer Laboratories, Inc.
15000 West 6th Avenue, Suite 300
Golden, CO 80401

IT St. Louis
13715 Rider Trail North
Earth City, MO 63045

Ecotek, LSI
3342 International Park Drive SE
Atlanta, GA

Environmental Science and Engineering
P.O. Box 1703
Gainsville, FL 32602-1703

Roy F. Weston, Inc.
208 Welsh Pool Raod
Lionville, PA 19341-1313

TCT-St. Louis
1908 Innerbelt Business Center Ave.
St. Louis, MO 63114-5700

11 DATA DOCUMENTATION

This section describes the measures necessary to ensure that physical data is recorded, interpreted, and reported in a manner consistent with the needs of the environmental documentation process. Areas which will be addressed in this section include field investigations, subcontractors, analysis and interpretation, and reporting. Relevant procedures governing data documentation are summarized in Section 10.

Details regarding specific data documentation requirements for individual activities defined in this document have yet to be developed. These requirements are typically developed during preparation of detailed work scopes and engineering specifications for individual activities.

The following sections discuss the criteria necessary to maintain the quality of physical data.

11.1 Field Investigations

A considerable amount of data will be recorded in the field. These data will include measurements of fracture spacing and orientation, geologic logging, water levels, pumping rates, sample locations, and various physical and ecological parameters. These data shall be recorded by Project Management Contractor (PMC) personnel, temporary duty personnel from other PMC contractor offices, or subcontractors. Weldon Spring Site Remedial Action Project (WSSRAP) Standard Operating Procedure ES&H 1.1.4 specifies the minimum type of information required when logbooks are used to document activities. Many activities, such as water level measurement, have standard forms which facilitate data reporting. In some cases, activities will be supervised by off-site engineers and work scopes will supply additional details concerning data recording needs.

The fundamental criteria for information recorded in the field is that field notes, or work sheets, should provide the proper level of detail so that individuals of appropriate experience and training should be able to utilize the subject information for its intended purpose in a spatially or temporally removed setting.

11.2 Subcontractors

The details regarding field records, data analysis interpretation, and reporting where subcontractors are concerned will be developed as part of the work scope and engineering specification for a particular work package. The PMC technical coordinator or cognizant engineer will provide development and review oversight to ensure that work scopes adequately address data collection, records, analysis, interpretation, and reporting requirements. Results shall be documented to a reproducible level, and the subcontractor will submit substantiation of an appropriate quality assurance/quality control (QA/QC) program. PMC technical oversight staff should consequently possess a demonstrated level of familiarity with the specific technical issue at hand.

All raw and reduced data collected by subcontractors will be included or appended in completion reports as defined by the engineering specification. Submission of electronic data will also follow formats described in the engineering specification.

The fundamental criteria for subcontractor-generated data are:

- Logbooks or standard forms must be maintained as detailed by contract specifications (see Section 11.1).

- Documentation of instrument calibration must be traceable to the National Institute of Standards and Testing (NIST).

- Calculations, raw data, and assumptions must be included which thoroughly support reproduction of reported results.

- Commercial or public-domain software used for data reduction or analysis must be thoroughly referenced.

- Citations and references must be included which support interpretations made from a set of individual calculations or results.

- Peer and management review requirements for calculations, drawings, and reports must be addressed in the contract specifications, and evidence of performance in peer and management review must be contained in the PMC subcontract file.

11.3 Data Reporting, Interpretation, and Documentation

The WSSRAP QA program for environmental data specifies numerous initiatives for each aspect of data documentation, interpretation, and reporting. The *Environmental Data Administration Plan* (EDAP) (MKF and JEG 1992a), a specific program-level plan, provides the foundation for collecting, verifying, validating, and interpreting data. The EDAP provides site-specific guidance for managing data and associated documentation and establishes general data quality goals. This plan also includes guidance on sampling-plan preparation, data verification, validation requirements, database administration, and data archival.

Site-specific procedures have been developed for all aspects of sample collection and handling. These procedures were developed from U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and other relevant guidance documents. They are reviewed annually and revised as necessary. Sampling personnel are trained in appropriate procedures prior to sample collection. All procedure training is documented and tracked so that personnel are retrained as procedures are revised. Variances or field modifications to procedures are noted in field notebooks and on sampling forms.

Laboratories analyzing WSSRAP samples are required to use standard operating procedures (SOPs) and to have a QA program. These quality assurance programs and SOPs are reviewed and approved by the Project Quality Department prior to commencement of analyses. Laboratories are also required to comply with WSSRAP-specific reporting requirements, thus simplifying data verification, validation, and interpretation. Laboratories are annually audited to ensure compliance with their QA programs and appropriate analytical procedures.

All data received from analytical laboratories are subjected to data verification. The data verification process is detailed in ES&H Procedure 4.9.1 and consists of a preliminary review of the quality-impacting aspects of sampling, analysis, and reporting. Data verification includes reviews of field sampling documentation, sample preservation, chain of custody, analytical holding times, and a comparison of electronic vs. hard-copy reporting. Data verification ensures that all data are received for every sample submitted for analyses and includes a preliminary review by the data users. The verification process also ensures that any discrepancies found are properly addressed and that the resultant changes are documented.

Data validation is performed independently of the analytical laboratory by the PMC Environmental Safety and Health (ES&H) Validation/Verification group. Data validation consists of two primary functions. First, the analytical process is reviewed and the quality of the data is documented. This consists of reviewing all records related to sample integrity, sample preparation, and the analytical measurement systems. Second, the data are compared to the method-specific criteria and site-specific data quality requirements (DQRs). This ensures that data quality is evaluated based on the end use of the data. At the WSSRAP, approximately 10% of all analytical data is validated according to site-specific procedures. The 10% validation actually reviews a large portion of the analytical lots, effectively validating a much larger percentage of the database. This is accomplished by reviewing information affecting data quality, such as instrument calibration, which is the same for all samples in an analytical lot.

The useability of the 10% data is established by data validation. The final step involves comparing results to the method criteria and DQRs. Qualifiers are attached to data records that have been validated. This allows data users to assess the quality of the data without a detailed knowledge of the analytical processes. The data validation process is detailed in ES&H 4.9.2.

The result of these programs and procedures is that analytical data quality is known and documented. The Phase I data will be summarized in an interim report and data quality objectives (DQOs) will be refined at that time. The data presented in the report will have been verified, and a percentage will have been validated. All raw and interpreted data collected for this sampling plan will be included as part of the *Remedial Investigation Report*.

12 HEALTH AND SAFETY

The health and safety of personnel performing the tasks described in this sampling plan are addressed by approved plans and procedures. The health and safety of Project Management Contractor (PMC) personnel performing sampling activities is addressed in Construction Management and Operations (CM&O) Procedure 15, *Task Specific Safety Assessment* (TaSSA). For each new task, a TaSSA will be prepared, reviewed, and approved daily when field activities are performed by PMC personnel. For repetitive tasks, a standardized TaSSA may be used if approved by CM&O; however, it must be reviewed, dated, and signed daily. The TaSSA ensures that potential hazards associated with the activities to be performed are reviewed, that personnel are aware of the potential hazards, that the proper protective measures are taken, and associated monitoring is performed.

Potential hazards associated with activities performed by subcontractors are addressed in Health and Safety Plans (HASPs). A HASP will be prepared for each subcontract to identify potential hazards, define minimum safety measures that must be implemented, and identify responsibilities for safety. Each HASP addresses general construction safety and the hazards related to performing the work in the specified area. In addition, subcontractors are required to submit, for contractor approval, a Safe Work Plan which incorporates requirements specified in the HASP. The subcontractors' field supervisor reviews the appropriate provisions of the Safe Work Plan with all field personnel daily. Subcontractors also receive oversight and personnel protection monitoring (if appropriate) from PMC personnel.

In addition to the provisions previously discussed, PMC Safety personnel routinely inspect work areas. Equipment is also inspected prior to use and routinely during use.

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14 ACRONYMS AND ABBREVIATIONS

AMSL	average mean sea level
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CEC	cation exchange capacity
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CM&O	construction management and operations
COC	contaminants of concern
CSP	Contaminant Sampling Program
DNT	dinitrotoluene
DO	dissolved oxygen
DOE	U.S. Department of Energy
DQO	data quality objective
DQR	data quality requirement
EDAP	Environmental Data Administration Plan
EE/CA	Engineering Evaluation/Cost Analysis
EIS	Environmental Impact Statement
EMP	Environmental Monitoring Plan
EPA	U.S. Environmental Protection Agency
EQAPjP	Environmental Quality Assurance Project Plan
ES&H	environmental safety and health
EU	exposure unit
gpd	gallons per day
gpm	gallons per minute
HASP	Health and Safety Plan
HISP	Hydrogeologic Investigation Sampling Program
HSL	Hazardous Substance List
MDNR-DGLS	Missouri Department of Natural Resources-Department of Geology and Land Survey
MDOC	Missouri Department of Conservation
MSL	mean sea level
NIST	National Institute for Standards and Testing
NQA-1	Nuclear Quality Assurance Program
NWI	National Wetlands Inventory
PAH	polycyclic (or polynuclear) aromatic hydrocarbons

PCB	polychlorinated biphenyl
PCOC	potential contaminants of concern
PMC	Project Management Contractor
QA	quality assurance
QA/QC	quality assurance/quality control
QAMS	Quality Assurance Management Staff
QAP	Quality Assurance Plan
QAPjP	Quality Assurance Project Plan
QROU	Quarry Residuals Operable Unit
QRRI	Quarry Residuals Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RPM	Remedial Project Manager
RQD	Rock Quality Designation
SARA	Superfund Amendments and Reauthorization Act of 1986
SC	specific conductance
SFMP	Surplus Facilities Management Program
SMP	Weldon Spring Quarry Supplementary Environmental Monitoring Investigations Sampling Plan
SOP	standard operating procedure
SOU	separate operable unit
SQP	Site Quality Procedure
TaSSA	Task Specific Safety Assessment
TCL	target compound list
TDS	total dissolved solids
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TOC	total organic carbon
TPHC	total petroleum hydrocarbons
TSS	total suspended solids
USGS	U.S. Geological Survey
VOA	volatile organic analysis
VOC	volatile organic compound
WSOW	Weldon Spring Ordnance Works
WSSRAP	Weldon Spring Site Remedial Action Project

APPENDIX A
Target Compound List

TARGET COMPOUND LIST

VOLATILE ORGANICS

Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethene
1,1-Dichloroethane
1,2-Dichloroethene (total)
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane
Carbon Tetrachloride
Bromodichloromethane
1,2-Dichloropropane
cis-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
trans-1,3-Dichloropropene
Bromoform
4-Methyl-2-Pentanone
2-Hexanone
Tetrachloroethene
Toluene
1,1,2,2-Tetrachloroethane
Chlorobenzene
Ethylbenzene
Styrene
Xylene (total)

SEMIVOLATILE ORGANICS

Phenol
bis(2-Chloroethyl)ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
2-Methylphenol
2,2'-oxybis (1-Chloropropane)
4-Methylphenol
N-Nitroso-di-n-propylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
bis(2-Chloroethoxy) methane
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
Hexachlorobutadiene
4-Chloro-3-methylphenol
2-Methylnaphthalene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronaphthalene
2-Nitroaniline
Dimethylphthalate
Acenaphthylene
2,6-Dinitrotoluene
3-Nitroaniline
Acenaphthene
2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl-phenyl ether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-methylphenol
N-Nitrosodiphenylamine (1)
4-Bromophenyl-phenylether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Carbazole
Di-n-butylphthalate
Fluoranthene
Pyrene
Butylbenzylphthalate
3,3'-Dichlorobenzidine
Benzo(a)anthracene
Chrysene
bis(2-Ethylhexyl)phthalate
Di-n-octylphthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo-(g,h,i)perylene

PESTICIDE ORGANICS /PCBs

alpha-BHC
beta-BHC
delta-BHC
gamma-BHC (Lindane)
Heptachlor
Aldrin
Heptachlor epoxide
Endosulfan I
Dieldrin
4,4'-DDE
Endrin
Endosulfan II
4,4'-DDD
Endosulfan Sulfate
4,4'-DDT
Methoxychlor
Endrin ketone
Endrin aldehyde
alpha-Chlordane
gamma-Chlordane
Toxaphene
Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260

METALS

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc
Cyanide

APPENDIX B
Existing and Proposed Groundwater Wells

Existing[a] and Proposed[b] Groundwater Wells

Hole ID	Coordinates		Formation/Group/Strata
	North	East	
MW-1002	1028904.73	428365.86	Decorah
MW-1004	1028652.82	428048.66	Decorah
MW-1005	1028594.54	427764.46	Decorah
MW-1006	1028600.92	428475.92	Alluvium
MW-1007	1028579.37	428471.14	Alluvium
MW-1008	1028535.75	428328.42	Alluvium
MW-1009	1028522.21	428364.21	Alluvium
MW-1010	1029020.15	430565.35	Alluvium
MW-1011	1029015.91	430555.82	Alluvium
MW-1012	1029137.25	427933.23	Decorah
MW-1013	1028247.32	427787.70	Decorah
MW-1014	1028242.51	427774.43	Alluvium
MW-1015	1028683.83	428683.21	Decorah
MW-1016	1028682.49	428669.94	Alluvium
MW-1017	1028492.99	428775.35	Alluvium
MW-1018	1028424.79	428511.20	Alluvium
MW-1019	1027991.05	428117.20	Alluvium
MW-1020	1027986.66	428107.71	Alluvium
MW-1021	1027860.48	427829.33	Alluvium
MW-1022	1027857.17	427819.39	Alluvium
MW-1023	1028493.58	428784.76	Alluvium
MW-1024	1029485.36	432809.93	Alluvium
MW-1026	1029061.22	427346.26	Alluvium
MW-1027	1028731.05	427494.85	Decorah
MW-1028	1028262.15	427200.83	Decorah/Plattin
MW-1029	1029001.27	428440.25	Kimmswick/Decorah
MW-1030	1028509.30	427625.97	Decorah

Existing[a] and Proposed[b] Groundwater Wells (Continued)

Hole ID	Coordinates North	Coordinates East	Formation/Group/Strata
MW-1031	1028257.00	427784.38	Plattin
MW-1032	1028526.26	428331.01	Decorah
MW-1033	1027985.27	428096.04	Plattin
MW-1034	1029275.46	427717.65	Kimmswick/Decorah
MW-1035	1029308.55	427092.75	Alluvium
MW-1036	1028803.77	427045.83	Alluvium
MW-1037	1028501.96	427005.86	Alluvium
MW-1038	1028443.99	427146.80	Alluvium
MW-1039	1028501.55	427327.62	Alluvium
RMW-1	1028734.68	430708.07	Alluvium
RMW-2	1027829.72	428353.45	Alluvium
RMW-3	1028569.33	429636.82	Alluvium
RMW-4	1028281.56	428898.22	Alluvium
PW02	1029122.40	433012.90	Alluvium
PW03	1028236.20	432666.90	Alluvium
PW04	1026963.90	432154.30	Alluvium
PW05	1027995.00	431703.10	Alluvium
PW06	1027079.50	431171.60	Alluvium
PW07	1026011.80	430684.50	Alluvium
PW08	1026957.80	430137.70	Alluvium
PW09	1026323.40	428932.60	Alluvium
MW-1044[c]	1028820	426840	Plattin
MW-1047[d]	1028260	427230	Alluvium
MW-1048[d]	1028315	428185	Alluvium
MW-1049[d]	1028465	427595	Plattin
MW-1050[d]	1028550	428050	Plattin
MW-1051[d]	1028665	428685	Plattin
MW-1054[d]	1028230	428365	Alluvium

Existing[a] and Proposed[b] Groundwater Wells (Continued)

Hole ID	Coordinates North	Coordinates East	Formation/Group/Strata
QAH-01[d]	1028760	427450	Angled Borehole (Decorah/Plattin/Joachim)
QAH-02[d]	1029110	427900	Angled Borehole (Decorah/Plattin/Joachim)
QAH-03[d]	1029130	427415	Angled Borehole (Decorah/Plattin/Joachim)

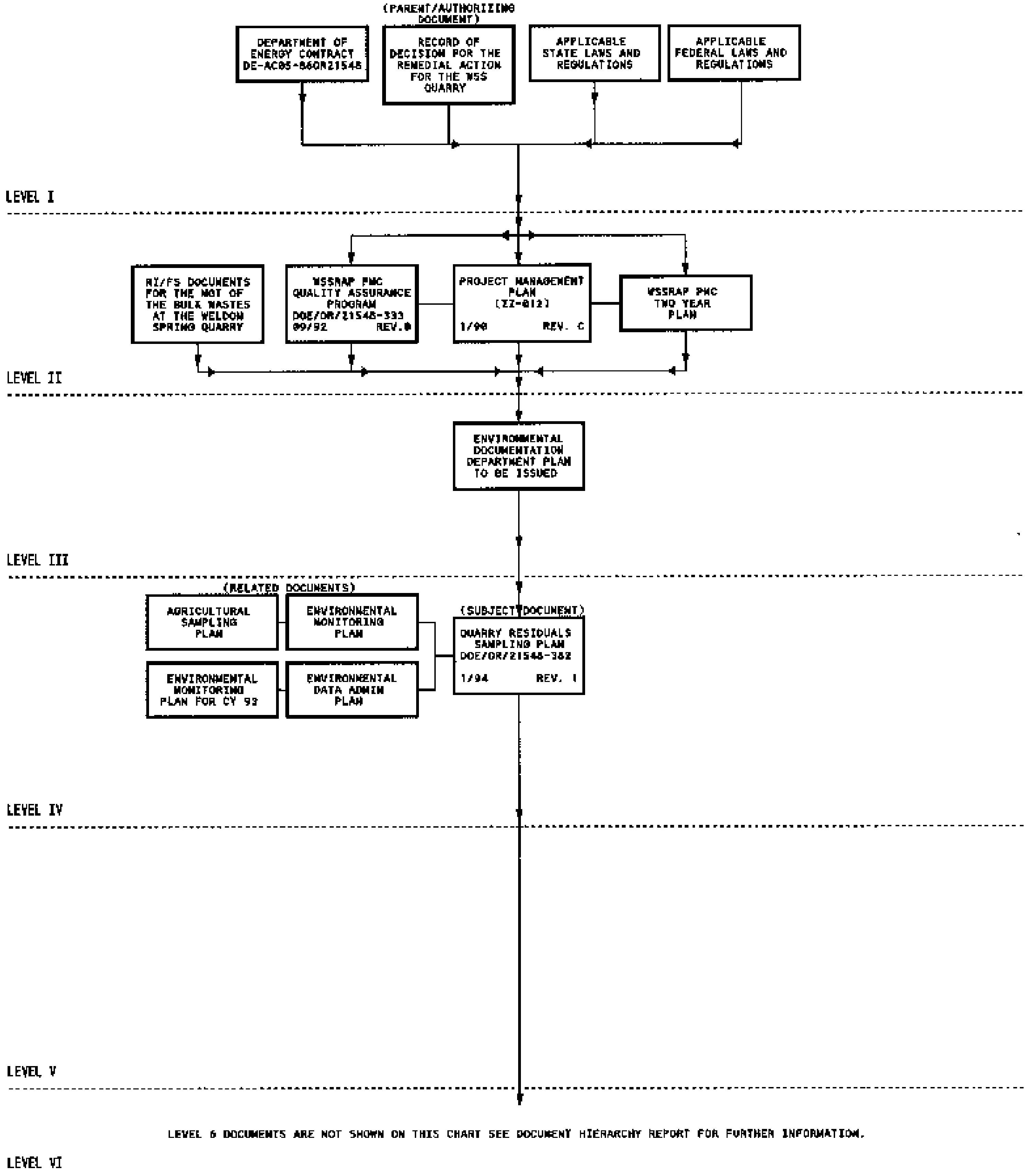
[a] MW Monitoring Well
PW Production Well
RMW St. Charles Co. Well
QAH Angled Borehole (Proposed)

[b] Coordinates for proposed wells are estimated; coordinates will be obtained by field surveying prior to and following installation.

[c] Part of *Supplementary Environmental Monitoring Investigation* (MKF and JEG 1992c).

[d] Proposed

APPENDIX C
Document Hierarchy



QUARRY RESIDUALS SAMPLING PLAN DOCUMENT HIERARCHY		
APPENDIX A		
REPORT NO. DOE/OR/21548-382	EXHIBIT NO.	
ORIGINATOR. BO	DRAWN BY. TLS	DATE. 01-21-1994

MK-Ferguson Company
Weldon Spring Site Remedial Action Project

TRANSMITTAL OF CONTRACT DELIVERABLE

Date: 12/21/95 Transmittal No.: CD-0088-04

Title of Document: Quarry Residuals Sampling Plan

Doc. Num.: 382 Rev. No.: 1 Date of Document: January 1994

Purpose of Transmittal: Request for Department of Energy acceptance of contract deliverable.

The Project Management Contractor has reviewed and approved the attached document and hereby delivers it to the U.S. Department of Energy, Weldon Spring Site Office.

The document will be considered accepted unless we receive written notification to the contrary within 30 days of the date of this transmittal.

James R. Powers

James R. Powers
Project Director

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